

ANNALS
OF
The Entomological Society of America

VOLUME XIII, 1920

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THE DEVELOPMENT OF ENTOMOLOGY IN
NORTH AMERICA.*

By W. J. HOLLAND.

The other day in one of the large astronomical observatories of our country the Director showed me some of the plates, which they are making in collaboration with other observatories, which have united to systematically photograph the whole of the sidereal expanse. The plates showed innumerable little white dots on a black background. The largest of these dots were not bigger than a small fly-speck. "How many suns are there?" I asked. "There are only about five thousand visible to the naked eye in both hemispheres," replied the astronomer, "but with the help of our improved telescopes, reinforced by photography, it is estimated that we can now locate about two millions of suns." "Just about the number of the species of insects, with which we entomologists have to deal," I answered, "and we have the advantage of being able to get at them and dissect them, and learn all about them, while you at the utmost can only learn a little about these stars."

"Natura maxime miranda in minimis."

But my theme this evening is not the vastness of the field of entomological research. When I was requested to address you, I chose as my subject the development of our science in North America.

The first studies of the insect-life of the New World were made by Europeans. We must not overlook the writings of the Spanish chroniclers, in whose pages we occasionally find ref-

* Annual address delivered before the Entomological Society of America, St. Louis, Missouri, December 30, 1919.

erences to the insects of the newly discovered lands. Oviedo as early as 1526 alludes to the abundant and torturing insect pests of the regions which he visited. At a later date Catesby and Sir Hans Sloane attempted an account of some of the species encountered in the Carolinas and the West Indies. Then came the immortal Linnæus and his disciple, Charles Clerck, who about one hundred and sixty years ago began to lay substantial foundations by naming, describing, classifying, and figuring many North American insects. Some of the remnants of the Linnæan Collection are still preserved at Upsala in Sweden, where I had the pleasure a few years ago of examining what is left of them.

Linnæus possessed an encyclopedic mind. His *Systema Naturæ* was a bold attempt to classify all the living organisms of which he had knowledge from the greatest to the smallest. No one of the sciences now comprehended under the great and inclusive term *entomology* but recognizes his influence. All students who make a study of the various orders of insects recognize that the Sage of Upsala was the first to blaze the way into fields, which, as the years have gone by, have seemed ever to expand, and to be more and more filled with wonders.

In the last two decades of the eighteenth and in the early years of the nineteenth century a number of Europeans amplified and extended the labors of Linnæus. The student of North American entomology recognizes his debt to Fabricius, whose writings must still be consulted by systematists. About this time Cramer issued his great work upon the lepidoptera exotic to Europe, the fourth and last volume appearing in 1782, being supplemented by Stoll, whose work appeared from 1787-1791, and who also published important works upon the hemiptera, homoptera, and orthoptera, which the student of today cannot neglect. Smith and Abbot's "Natural History of the Rarer Lepidopterous Insects of Georgia," issued in two folio volumes in 1797, is one of the monumental works of this period. It must always be occasion for regret that the original drawings made by Abbot of the insects belonging to other orders which he depicted, the originals of which are preserved in the British Museum, were not published. Abbot was a careful observer and an accomplished draftsman, whose work deserved a better fate than to be simply buried in the portfolios where they still may be seen. To this period also belong the writings of Latreille,

and others of the encyclopedists, who collaborated with him, notably A. G. Olivier.

A work of great beauty for the times, which began to appear in 1806, is Hübner's *Exotische Schmetterlinge*. It continued to be issued until 1824, and was supplemented from 1818-1832 by Carl Geyer. In this quite a considerable number of North American lepidoptera are represented for the first time by recognizable figures. We also must not forget the writings of Palisot de Beauvois.

The earliest paper written by a native of America upon an entomological theme to which I have been able to find reference is an article by John Bartram, who was born in 1701 in Pennsylvania, and who in the *Philosophical Transactions*, published in London in 1745, gives "An Account of Some Very Curious Wasp-Nests of Clay in Pennsylvania," accompanied by a figure. He subsequently contributed several other brief entomological papers to the same journal. Moses Bartram, his son, in 1766 wrote an article entitled, "Observations on the Cicada or Locust of America, which Appears Periodically Once in 16 or 17 Years." This was published in 1767 in the *Annual Register*, the editor of which states that the paper had been "communicated by the ingenious Peter Collinson." The name of Collinson is perpetuated in the genus *Collinsonia*, one of the *Labiatae*. Collinson aided Linnæus, the author of the genus, by sending him collections of exotic plants.

The real beginning of an indigenous literature dealing in a truly scientific manner with entomological subjects is found in the writings of Thomas Say, the Patron Saint of our Society, who was born in Philadelphia in 1787, the year in which the Northwest Territory was organized by the Congress of the Thirteen States, and in which the General Assembly of Pennsylvania granted the first charter for an institution of learning west of the Allegheny Mountains to the school, which is now the University of Pittsburgh. Thomas Say was one of the founders of the Academy of Natural Sciences in Philadelphia, which celebrated its centennial in 1912. The first paper from his pen, dealing with entomology, was entitled "Description of Several New Species of North American Insects." It appeared in the *Journal* of the Academy in June, 1817, being pages 19-23 of the First Volume of that important publication.

Only two years more than a century have elapsed since this first article upon entomology from the pen of Thomas Say was published. In this century there has occurred upon American soil an enormous extension of entomological research. The century must, however, be divided for our purposes into two epochs, one preceding the great Civil War, the other following it.

The epoch preceding the Civil War was far less fruitful than that which succeeded it. An examination shows that prior to 1865 the number of laborers in the field was small, and that among those engaged in studying North American insects European students and writers still outnumbered those upon the soil of the New World. The publications of native Americans, though valuable, were not numerous. The economic importance of entomology was not generally recognized. The impulse toward biological research, which arose after the announcement of the doctrines of Darwin, Wallace, and their fellow-laborers, had not yet been felt.

The principal repositories of entomological information in North America during the first half of the nineteenth century are periodicals which were issued by a limited number of learned societies. The Academy of Natural Sciences in Philadelphia led the way with its *Proceedings*. The American Philosophical Society, which had been founded earlier than the Academy of Natural Sciences, became the sponsor in its *Transactions* for a number of papers written by Thomas Say, the first being "A Monograph of the Genus *Cicindela*," which was followed by others. Both of these publications became favorite media for the followers of Say in which to announce their discoveries, and the results of their studies. In 1834 The Boston Society of Natural History was formed. Among its earliest publications were two papers, one upon "North American Coleoptera," the other upon the "Hymenoptera of America," written by Say, but which did not appear until some time after his death. In addition to these publications I may mention "The Annals of the New York Academy of Sciences," numbering thirteen volumes, beginning in 1819, and thereafter continued at irregular intervals; "The Annals of the Lyceum of Natural History of New York," the series extending from 1824 to 1877; the "American Journal of Science and Arts," often spoken of as "Silliman's Journal," the entomological content of which is relatively small, though important; "The Proceedings

of the California Academy of Natural Sciences," which began to appear in 1854. The first series of this latter journal consists of seven volumes, in which there are a number of valuable papers upon entomological subjects from the pens of Dr. Herman Behr, Henry Edwards, and others. It is a set of books now hard to get, as the greater part of the volumes were burned in a fire. In 1848 the Smithsonian Institution began to publish, and in the "Smithsonian Miscellaneous Collections," and the "Smithsonian Contributions to Knowledge" there were issued some important entomological papers.

Shortly after Say had begun in Philadelphia to give to the world the results of his researches, Thaddeus William Harris in the "New England Farmer" and the "Massachusetts Agricultural Repository" commenced to publish upon the Insects of Massachusetts, and continued until his death in 1856 to write instructively upon various insects injurious, or useful, and contributed a number of important papers of a descriptive and systematic nature to the literature. Harris was only second to Say as a pioneer in this field of inquiry, and his "List of the Insects of Massachusetts," published at Amherst by Professor Hitchcock in 1833, and his "Report on the Insects of Massachusetts Injurious to Vegetation" (which in an edition revised by Flint, is still a classic) greatly helped to develop an interest in economic entomology.

There were a few ardent and industrious students of entomology in the United States who labored during the half century preceding the Civil War besides those whom I have already mentioned. We owe gratitude to Melsheimer, Haldeman, Baron Osten Sacken, (the latter a member of the Russian Legation in Washington) and to Morris, as well as to Hagen, who was an importation from Europe, brought over by the elder Agassiz. Beside these there were a score or more of others, who were collecting, studying, classifying, preparing to give to the world the results of their labors, but belonging to a younger generation which was just about to appear upon the stage. They may be said to have been simply pluming their wings for flight at the end of the epoch of which I am speaking. They were triumphant in achievement at a later date, and a few, very few of them, survive to this day as the grizzled veterans of half a century ago.

I can still very vividly recall the later years of the epoch of which I have been speaking, and no doubt a few of my hearers this evening, whose memories take them back to their early days in school and college "before the war," can do as much. As a boy I had become interested in the study of insects. The only works upon the subject to which I had access at the time were an original copy of Say's "American Entomology," Jaeger's "Life of North American Insects," and Boisduval and Leconte's "Histoire Générale des Lépidoptères de l'Amérique Septentrionale." These books were supplemented through the kindness of an obliging congressman by the Annual Report of the Smithsonian Institution for 1858, containing instructions for the collection of insects, which I liked better than my catechism, and subsequently by a copy of Morris' "Catalogue." This was the sum of literature accessible to me. When I went to college at Amherst it was with a feeling of eagerness, founded upon a conviction that the doors of knowledge would at last be opened to me. I had collected a multitude of specimens, many hundreds of species in all orders. Imagine my despair when I asked my most genial instructor, Professor Edward Hitchcock, for assistance and guidance in determining my insects, to have that hearty and bluff worthy say to me: "Holland, there is not a man in Amherst who knows the first thing about insects." Professor C. B. Adams, the great naturalist, who, I had been told, had sometimes rocked me in my cradle in my West Indian home, where he lived during his stay in Jamaica, was dead and gone; his Jamaican insects in the Appleton Cabinet had mostly been devoured by *Dermestes*; I could do nothing, and therefore promptly gave up entomology and devoted myself to chemistry, geology, and botany, for teaching which there was more ample provision made. It was not until years later that I came back with vigor to the love of my boyhood. Blake, Cresson, Strecker, Scudder, Leconte, Horn, Grote, Henshaw, and many others were hard at work at that time, but I knew it not. I came to know them all in later years. But at that time there was no one to guide me. There was no army of entomological enthusiasts such as is found in our society with its membership of hundreds. The science had few votaries. They lived apart; their work had barely begun to see the light; and I knew them not.

We now come to the second epoch. On March 12, 1861, the Entomological Society of Philadelphia was constituted, being

the first entomological society formed in the New World. In 1867 its corporate name was changed to "The American Entomological Society." It published under its earlier name six volumes of *Proceedings*, and in 1867 began the publication of the "*Transactions of the American Entomological Society*," now numbering forty-five volumes. The activities of this important association led to emulation in other parts of the country. It was followed gradually by the organization of kindred societies in Cambridge, Brooklyn, New York City, Washington, and elsewhere. All of these associations began to publish sooner or later.

The economic importance of our science began to be more generally recognized. A very great influence was exerted in this connection by the labors of a young entomological enthusiast who had recently left his home in England and come to the city of St. Louis, where we are assembled this evening. At the early age of twenty-five years, in 1868, Charles Valentine Riley was made the State Entomologist of Missouri. He began the publication of his "Reports," continued until 1877. They are to this day most valuable. In 1878 he was put by the Government of the United States in charge of a Commission appointed to investigate the ravages of the Rocky Mountain Locust. Later he was transferred to the Bureau of Entomology in the Department of Agriculture in Washington. The successful administration of the Bureau from 1881-1894 was largely due to his initiative and to the fact that he had a genius for calling to his aid men of the greatest competence. His successor is our friend and fellow-member, Dr. L. O. Howard. *Serius redeat in calum!*

Among the men who were the cotemporaries of Riley, and even his predecessors, there should be mentioned Professor B. D. Walsh, and the late Dr. Asa Fitch, both of whom rendered distinguished services in the fields of pure and applied entomology. The labors of Walsh related to the insect-life of Illinois and the Mississippi Basin, Fitch dealt with the insects of the State of New York. The writings of both of these learned men are exceedingly valuable.

An impetus to the study of entomology in North America was not only given by the establishment of the Bureau of Entomology in Washington, but by the establishment of agricultural schools and colleges in the various states under the provisions of the "Morrill Land Grant Act," which was passed

on July 2, 1862, and was later thrice amended. An impulse was also received from the subsequent foundation of experiment stations, most of them in connection with the Land-grant Colleges. There also took place throughout the country a quickening of interest in so-called "Nature-studies," which has become intensified with the lapse of years. Entomology has found its way into the curricula of a number of the higher institutions of learning, and to some extent obtains a foothold in the schools of elementary grade in a number of the States. The ease with which material for study can be obtained in this branch of science, the wide range of biological facts which are brought into view, as well as the curious structure and beauty of many insects, appeal to many minds. While our science has not as yet assumed the same prominence which is accorded to botany in the curricula of institutions of learning, it nevertheless cannot any longer be regarded as an unpopular study.

I have alluded to the important influence exerted by the governmental recognition of the economic importance of entomology as having had its influence in the development of the science, and the multiplication of students in its various branches, but we ought not to fail to remember how large is the debt which is owing to the labors of individuals, who had little or no support in their labors from the governments of the States or from that of the Nation. Many of the foremost laborers in the field had to depend entirely, both in the prosecution of their researches and in the publication of the results, upon what their own pocket-books could provide, or upon the scant assistance which was given them by the learned societies to which they happened to belong. We are under profound obligations to the self-denying and patient labors of such men as Philip R. Uhler, Samuel H. Scudder, Alpheus S. Packard, William H. Edwards, Henry Edwards, John L. LeConte, and Dr. George Horn, to mention only a few of the illustrious dead, who brought to their work magnificent intellectual power, profound learning, great experience, and unquenchable enthusiasm. I have personal knowledge of the great sacrifices made by these men in their efforts to pave the way for those who should come after them. At great cost without hope of reward they laid the foundations upon which we are still building. None of the men of whom I am speaking, unless it be Packard and Scudder, received even indirectly assistance from the public

treasury. Two of Packard's great monographs were indirectly published at government expense; and Dr. Scudder's monumental work upon fossil insects and his indispensable "*Nomenclator Zoologicus*" were issued under governmental auspices. Otherwise these most prolific writers were compelled to depend upon their own resources or upon such help as could be derived from the learned societies, with which they were affiliated, or the serial journals, the pages of which were open to them. I recall in this connection the fact that the late William H. Edwards being desirous to publish the third volume of his "Butterflies of North America," a very expensive undertaking, wrote to me saying that in order to secure the necessary funds he had determined to offer his entire collection to the Trustees of the British Museum, hoping that they might purchase it, as they had already purchased the collection of A. R. Grote, containing his types of the moths of North America. I forthwith wrote to him, proposing that I would assume the expense of publishing the third volume of his work, provided that the collection should be ultimately turned over to me. The offer was promptly accepted. I only mention the incident, because it throws light upon the difficulties under which some of the most important works at our command were brought into being by their authors. Dr. Scudder told me that his "Butterflies of New England" had involved a personal outlay on his part of nearly ten thousand dollars, and that he would deem himself fortunate if the sales ultimately should return to him the capital he had invested, not speaking of the time and labor he had expended. Many of the most important works we possess are due to individual initiative in their conception and execution. A very remarkable work of this sort, which it might have been the glory of a nation to produce, is the *Biologia Centrali-Americana*, which stands as a monument to the learning and the generosity of a wealthy Englishman, my friend, the late F. Ducane Godman. Parts of this colossal work were written by Americans, notably the Section dealing with the Diptera, which was produced by our lamented colleague, Professor S. W. Williston.

Proceeding to a somewhat closer review of entomological activity in North America during the past fifty years, it is seen that the number of periodicals accessible to entomologists, who may desire to publish their observations, has been greatly

increased. In the year 1860 there were only five or six such journals; today there are about fifty. Of course not all of these are of equal importance and dignity. The day, however, is past when a student of entomology in North America need fear that his work, if of value and significance, need long languish in darkness, and fail to be made known to his fellow-laborers.

Another fact worthy of note is not merely the multiplication of learned societies to which I have already alluded, but of institutions for research and for the promotion of a knowledge of the natural sciences. In 1860 there were only half a dozen museums in the new world, and these were quite in their infancy. Today there are a multitude of museums, some of them well-housed, well-equipped, and well-supported, which are fit to become the ultimate repositories of important entomological collections, and there are a number of endowed institutions, which in a broad manner promote intensive studies in natural science.

In 1860 the number of men and women engaged in entomological pursuits in the United States and Canada were numbered by scores; today they are numbered by thousands.

In 1860 there was not a single manual dealing with the science issued from an American press. Packard's "Guide to the Study of Insects" was the first to appear, and it came out in 1869. Today there are a number of textbooks easily available, and the young man or woman who wishes to make a serious study of the subject is not forced to fall back, as we, their elders, were, upon the pages of European writers, such as Burmeister.

The literature needed by the specialist in 1860 was scanty. Today it has grown to be so enormous that complaint is being made. Our greatest need at the present time is condensation. Compact manuals covering the various branches of the science are called for. Hand-books, such as the botanists have provided, covering the various orders, should be prepared.

In speaking of the growth of the literature of our science in America, I have been interested in examining the lists of entomological publications furnished by the "Zoological Record." In the year 1864, when that journal first appeared, one hundred and forty-nine papers upon entomology are listed, only five of which are from the pens of North American writers. I am quite sure that the figures given for that year are incorrect.

The learned editors did not have access to, or accidentally overlooked a number of papers, which in that twelvemonth were published by American students. But they also overlooked the writings of a number of authors in other lands. For purposes of statistical comparison we may accordingly accept their figures as approximately correct. It appears in consequence that only 3.3 per cent of the entomological literature of the year 1864 was American in its origin. The "Zoological Record" for 1913 lists 2967 papers upon entomology, which had fallen under the eyes of the compilers. Of these 627, or more than 21 per cent, were written by Americans or Canadians. In 1916, owing to the war, the number of contributions to scientific literature fell off very greatly. Only 1821 papers upon entomological themes are listed by the "Zoological Record" for that year, 1146 less than in 1913. Of this total 557 were published by citizens of the United States and Canada, more than 30 per cent of the total number of titles. In view of the fact that the "Zoological Record" seldom takes account of any but papers having taxonomic import, and that the vast body of papers dealing with economic questions in the field of entomology are not recorded, save exceptionally, these figures have great significance as showing the wonderful increase which has taken place in entomological activities in North America during recent years. The output of literature in our science has been multiplied ten-fold among us in the past five decades.

Another evidence of progress is discovered when we examine into the lists of species known to occur in North America, comparing them with earlier lists, so far as such exist. Taking up the "Catalogue of the Described Lepidoptera of North America," prepared by the Rev. John G. Morris and issued by the Smithsonian Institution in May, 1860, we find that he enumerates for the whole continent from Labrador to Panama, only 328 diurnal lepidoptera, or butterflies, of which 225 belong to the region called Boreal America by some, or by others the Nearctic Region. The latest check-list, published by Barnes & McDonough, enumerates 661 species of butterflies as occurring in Boreal America. There have thus been added to the faunal list 436 species, the number given by Morris having been approximately trebled in the past five decades. There is even a greater advance shown in the case of the *Heterocera*, or moths.

Morris gives the number of species of moths credited to the North American continent, of which he had knowledge, as 1340, a large number of which belonged to the Neotropical Area. Barnes & McDonough, restricting themselves to Boreal America, list 7834 species as belonging to our fauna. The number of species of *Heterocera* known to occur in Boreal America has therefore since 1860 increased at least seven-fold.

What I have stated as to the Lepidoptera is typical of what has taken place in the other orders. The earliest list of beetles was prepared by Melsheimer, who confined himself to those species, which he knew to occur in Pennsylvania. He catalogued 1363 species. Crotch's Check-List, published in 1873, enumerated 7450 species of beetles found north of the Rio Grande of Texas. The supplement to his List by Austin raised the number to 9704 in the year 1880. The Revised List by Henshaw, with the Supplements, brought the total to 11,256 in the year 1895. The Catalogue by C. W. Leng, which will appear shortly, is reported to bring the number of species known in this faunal area up to 18,547 species, exclusive of sub-species and varieties.

The writings upon the Diptera by Osten Sacken and others, which appeared about 1860, yield upon examination a total of known species in this order of less than 1,000. The great Catalogue prepared by our distinguished colleague, Dr. J. M. Aldrich, issued in 1905, gives a total of species found on the continent from the highest north to Panama of 9350. Some of these species may not be valid, but most of them are, and the field has only been partially explored.

In all the other orders a similar increase in the number of known species has taken place, and where at the beginning of the epoch only a few hundreds of species at the most were listed, we now discover that there are thousands known.

To have prepared an approximately correct estimate of all the recorded species in all the orders ascertained to be found upon the soil of the United States and Canada is a labor for which I have not had the necessary time. It would have required the careful examination of hundreds of papers, and extensive use of my adding-machine. I venture the statement, however, that there are probably not far from 60,000 species known, or in process of being named and described. Not more than one-sixth of these were known to science fifty years ago.

There has been prodigious activity along taxonomic lines displayed by students of the subject during the past five decades.

One of the most marked developments of the past half-century has been the growth of interest in the economic aspects of entomology. I have alluded already to the work done by Harris, Walsh, Fitch, and Riley. These men have had an army of enthusiastic successors, among them some who have rivalled and even surpassed the most excellent labors of those I have just named. Most of them are still with us, including our Nestor, Dr. Stephen A. Forbes. An English entomologist of renown, speaking to me some time ago of certain entomological reports which he had received from the United States Department of Agriculture and from various Agricultural Experiment Stations, said: "We have nothing like this in the Old World. The United States and the several States are greatly in advance of the European nations in your application of science to the arts of the agriculturist. I marvel at what you are doing."

But it is not only in connection with agriculture that the entomologist has proved his worth, but also in the field of medicine, as you are well aware. The study of disease-bearing insects, and the ascertainment of methods of prophylaxis are fields in which American students of our science have achieved results, which must prove of incalculable service to coming generations. May I say a word in this connection concerning the splendid "Monograph of the Culicidæ" in four great quarto volumes, prepared by our colleague, Dr. L. O. Howard, and his associate, Messrs. H. G. Dyar, and F. Knab which has just been published by the Carnegie Institution of Washington. I have carefully examined it, and am sure that it is the best piece of work in our science which the Carnegie Institution has thus far been allowed the privilege of publishing. For years to come it will be the standard work of reference for students in this difficult field of investigation.

Another sphere in which there has been marvelous progress not only in our country, but throughout the world, is that of technique. I might spend hours in speaking of this, but must content myself with a few words only. There has been a wonderful advance and improvement in the instruments and methods of research. Take that familiar tool, the microscope, which we all must constantly use, how wonderfully has it been improved! We have in the Carnegie Museum a microscope

which in 1736 was presented by Linnæus to his fellow-student and friend, Bernard Jussieu, when they were students in Paris. It is for that day a good instrument, and I can still see through it, but there is a gulf between it and the instruments we employ today as wide as that between a toy pop-gun and the French 75s, which roared forth victory on the European battle-front. Take such a simple commodity as insect-pins as an example of what the use of modern machinery can accomplish. Pins in the days of Linnæus were made by hand; they were costly; they were clumsy. For mounting the minuter forms the best Linnæus had were about as good as marlin-spikes. Take the thousand and one odds and ends of apparatus which we employ in our work, how marvelously have all these things been improved! Photography has come to our aid, and with its help we are able to get and keep records, which the fathers would not have dreamed to be possible. As I sat and listened yesterday and today to the fine papers which were being read, and which were being illustrated by magnificent projections with the help of the electric lantern, I could not help in thought contrasting the present with the past, and wondering whether you younger men appreciate the inheritance into which you, through the labors of others, have come.

The review I have made is necessarily brief. I cannot avoid thinking that it should awaken in us satisfaction. The great field which is ours has at least been partially conquered. There remains, however, a vast amount of work to be done; it is far from being exhausted. Of only comparatively few species are the life-histories thoroughly known; the phylogenetic relationships of various groups and species await investigation; no doubt there are thousands of species yet to be discovered and named; and, in spite of the fine work done by Scudder and by Cockerell in paleontology, there must be innumerable species of fossil insects to be found and described. Many questions in economic entomology still await solution. There is reason, therefore, for you younger men to regard the future with hope and pleasurable anticipation. I am sure from what I have seen during the sessions here that we have before us a future still more brilliant than the past has been.

In conclusion, in these times of strife and discord it is a pleasure to recall how fraternal have been the relationships which have been maintained by all workers in our special field

of inquiry. I desire especially to emphasize the cordial relationships which have been maintained during all these years between students living south of the St. Lawrence with those living north of that river. One of the best of all the entomological journals on the Continent is the "Canadian Entomologist." As it is one of the oldest, so it is one of the best-sustained publications of its kind. "The Entomological Society of Ontario" is a splendid organization, in which most of the leading workers within the United States have felt it an honor to have membership. For all practical purposes the entomologists of British North America and of the United States form one united brotherhood. Behold how good and pleasant it is for us thus to dwell together in unity! May I not express the hope that the friendly relationship which has so long been maintained among us may remain indissoluble, and the same spirit which has prevailed between these two great bodies of workers in the New World may extend to all brotherhoods of other nations, and that through our scientific friendships we all may help to bring in the reign of universal peace, the thought of which is dominant among us, and is emphasized by the anniversary of the birth of THE PRINCE OF PEACE, which we have just celebrated.

THE MUSCULAR SYSTEM OF GRYLLUS ASSIMILIS FABR.
(= PENNSYLVANICUS BURM.)

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INTRODUCTION.

This paper gives an account of the musculature of *Gryllus assimilis* Fabr., one of our common field crickets. It includes also a brief description of the internal skeletal structures inasmuch as a knowledge of these is necessary to understand the method of attachment of the muscles.

In his comprehensive study of the thorax of *G. domesticus* Voss ('05) describes the musculature of the veracervix, the thorax and the anterior segments of the abdomen. Berlese ('09) figures some of the thoracic muscles of *G. campestris*. The musculature of these two insects agrees very closely with that of the allied *G. assimilis*.

In naming the head muscles, including those of the neck, I have employed terms descriptive of their functions without reference to possible segmental homology. I have followed Voss and Berlese's system in naming the thoracic and abdominal muscles, and have not described these muscles in detail, owing to their general similarity to the muscles of *G. domesticus* as described by Voss ('05). The numbers used by Voss are inclosed in square brackets after the description of the muscles; the names which he used for the cervical muscles are also thus inclosed, Crampton's term *veracervix* being substituted for *microthorax*.

I have thought it best to avoid the use of Latin terms. The numbers used have no significance apart from their reference to the figures.

I. THE ENDOSKELTON.

(Figs. 1, 2 and 3).

THE HEAD (Fig. 2). The well developed tentorium consists of a central plate (T.C.) from which two pairs of processes are given off. The base of the central plate forms the ventral edge of the occipital foramen (F.O.) The central plate lies in a horizontal plane approximately parallel to that passing through the median lines of the pleura. A constriction near the base gives this plate a more or less urn-shaped outline. At each of its apical angles it bears a large triangular anterior plate (T. A.), the base of which is attached to the lower edge of the gena near the base of the mandible. Immediately behind these processes second and smaller pair arises from the central plate. These are the posterior processes (T. P.); they are columnar in form and run obliquely forward and upward, fusing with the epicranium near the base of the antennae. Between the two anterior processes, the central plate and the epicranium, three foramina are formed, an anterior one (F. A), through which the oesophagus passes from within the epicranium to the mouth, and two lateral foramina (F. L.) through which the crura cerebri and the adductor muscles of the mandibles pass.

Three tuberculate apodemes arise from the epicranium at the edge of the occipital foramen, a median dorsal process (A. M.) and two lateral processes (A. L.) These processes serve for the insertion of certain of the muscles which move the head.

THE VERACERVIN OR NECK. (Fig. 1, Cerv.) There are five paired and one unpaired sclerites which support the cervical membrane and on their inner surfaces serve as points of attachment for some of the neck muscles. These are the three intersternites (Fig. 1, i.st. γ , δ , ϵ) or ventral cervical sclerites, the second of which is median and unpaired; the large interpleurite (Fig. 1, i.p.) bearing an inward projecting process (ap. ip.) at its anterior end, and the two intertergites (Fig. 1, i.t. α & β) or dorsal sclerites. The form and arrangement of these sclerites may be readily seen by referring to Fig. 1. As will be shown later the interpleurite is the only one of much importance for the attachment of muscles.

THE PROTHORAX (Fig. 1, T₁). A lateral entosternite or furca (es) arises from each of the posterior ends of the inverted V-shaped furcasternite (Fs) and extends across the opening of the fore-leg. The flattened distal portion is closely appressed to the inner face of the epimeron and entopleurite. The small spina or median entosternite (es. m) is a flattened three-lobed plate arising from the posterior edge of the spinasternite (Ss). The greater portion of the pleuron is overgrown by the pronotum and lies on the inner side of this sclerite (see DuPorte, '19). The contiguous edges of the episternum (Ep) and epimeron (Em) are infolded to form a deep entopleurite (ep) which projects ventrally to form a ball and socket articulation with the outer angle of the coxa.

THE MESOTHORAX (Fig. 1, T₂). The median entosternite (esm) or spina is a three-lobed disk attached by a short stalk which projects inwards from the furcasternite between the bases of the lateral entosternite (es). The proximal section of the lateral entosternites is more or less cylindrical, while the distal section is expanded and folded to form a pocket into which fits a process from the entopleurite. The entopleurite (ep) is formed from the inflexed contiguous edges of the episternum and epimeron. Its dorsal extremity projects beyond the edges of the episternum and epimeron, forming the pleural wing process. At its ventral end it gives off a spur-shaped pleural process which fits into the pocket of the entosternite. The two are connected by a pair of short muscles, one originating from either side of the spur and inserted on the inner sides of the pocket. Thus a strong arch is formed above the leg opening. From this arch certain of the leg muscles originate.

A pair of intersegmental sclerites (in), probably the pretergite, lies transversely in the sutural membrane between the pronotum and mesonotum, the inner ends are attached to the anterior edge of the mesoscutum and the outer ends extend to the anterior edge of the base of the wing near the anterior piece of the first axillary. There is a large basalar sclerite (b.s.) and a small subalar plate (s.a.p.)

THE METATHORAX (Fig. 1, T₃). The endosclerites in this segment are similar to those of the mesothorax, except that there is no median entosternite. The intersegmental sclerite (in₂) comes in close contact with the posterior process at the lateral end of the meso-postscutellum. There are one large and

one small basalar sclerites (b.s.) and two subalar plates (s.a.p.), the anterior one elongated, the posterior smaller and broadly oval.

THE ABDOMEN (Figs. 1 and 3). Several small chitinous plates are imbedded in the pleural membrane of the abdomen. The parasternal plate (Fig. 1, ps.p.) situated immediately behind the base of the third coxa, is the largest of these sclerites. Judging by its musculature this plate is apparently a detached portion of the first and second abdominal sternites. In each segment from the third to the seventh there are three small linear pleural sclerites, one (p.s₁) near the anterior end, one (p.s₂) near the posterior end and the third (p.s₃) in the middle of the segment nearer the tergum than the two other pleural sclerites. In the third segment the third pleural sclerite is large and receives muscles from the second and third sternites.

From the anterior edges of the eighth and ninth tergites in the female, a flattened blade-like process (Fig. 3, PA₈, PA₉) projects forward. These processes serve as points of origin for certain of the muscles which move the ovipositor. The supra-genital plate bears a median knife-like process (Fig. 3, P.S.G.) which serves the same purpose.

A ventral (Fig. 3, v₁, v₂) and a dorsal process (d₁, d₂) are given off from the base of each gonapophysis; these serve as points of insertion for muscles of the ovipositor. On each side the two dorsal processes (d₁ and d₂) are closely interlocked. The ventral processes (v₁) of the dorsal pair of gonapophyses (G. D.) are connected by means of a transverse chitinous rod (Fig. 3, t.c.) which bears a flat, thin unpaired process (m) in the middle of its anterior face.

II. THE MUSCLES OF THE HEAD.

The muscles of the head may be divided into (a) the muscles of the mouthparts, (b) the muscles of the antennae, (c) the muscles of the pharynx and oesophagus, and (d) the cervical muscles, or those which control the movements of the head as a whole.

(a). *The Muscles of the Mouthparts.*

THE LABRUM.—The *Abductors of the Labrum* (Figs. 7 and 9, abd.lbr.) are a pair of contiguous muscles, straight with parallel

fibres, originating in the middle of the front immediately beneath the median ocellus and inserted by a short tendon into the base of the labrum, one on each side of the median line.

The *Adductors of the Labrum* (Figs. 7 and 8, ad. lbr.) Two three-headed muscles inserted by means of a small tendon, one in each of the basal angles of the labrum. The outermost head is attached to the front near the inner side of the antenna, the innermost near the median line adjacent to the origin of the abductor, and the middle head midway between these two. In some specimens only the outer and inner heads were present.

THE MANDIBLES are articulated with the epicranium by means of a ginglymus joint permitting motion in one plane only, consequently there are but two muscles, an adductor, and an abductor. The *Adductor of the Mandible* (Figs. 4, 5 and 6, ad. md.) is a pyramidal complex muscle and, owing to the fact that in the cricket the mandibles are strong crushing jaws, is the largest and strongest muscle in the head. Its base occupies the whole top of the head as far forward as the eyes and upper edge of the brain. It is inserted into the inner angle of the base of the mandible by means of a large tendon composed of three flat transparent laminae (Fig. 4, t).

The *Abductor of the Mandible* (Fig. 4, abd. md.) is smaller and has its origin in the epicranium beneath and behind the eye. It is inserted into the outer angle of the mandible by means of a long flat tendon.

THE MAXILLAE. Owing to the segmented structure of the maxilla, its muscles are more numerous and complicated than those of the labrum and mandible. The *Abductor of the Maxilla* (Figs. 12 and 14, abd. mx.) is a thick triangular muscle originating in the gena and postgena near the origin of the abductor of the mandible. It is inserted by means of a long narrow three-faced tendon into the inner angle of the second segment of the cardo. The hinge on which the maxilla turns lies mesad of the insertion of the tendon along the upper edge of the proximal segment of the cardo (i. e., the edge near the letter C₁ in Fig. 14). The opening of the maxillae therefore causes a pushing upwards of the outer portions of their bases (the outer edge of C₂). Conversely the upward pull given to this portion of the maxillae by the contraction of the abductors causes them to open.

There are two *Adductors of the Maxilla* which both take their origin in the lower surface of the central plate of the

tentorium. The *First Adductor* (Figs. 13 and 14, ad. mx.) is inserted into the first segment of the cardo at its junction with the second segment near the insertion of the abductor. The *Second Adductor* (Figs. 12 and 14, ad. mx.) is also inserted into the cardo but at the outer angle of the second segment near the suture between the cardo and the stipes.

The *Flexor of the Maxilla* (Figs. 13, 14 and 16, fl.mx.) is a strong compound muscle which also originates from the lower face of the central tentorial plate. It is inserted into a flat elongated apodemal surface (Fig. 15, ap.st.) along the inner edge of the outer wall of the stipes. This muscle and the two adductors working together are capable of exerting considerable force in the closing of the maxillae.

The *Flexor of the Lacinia* (Fig. 14, fl.lac.) lies wholly within the stipes. It originates by a broad head near the outer angle of the base of the stipes, runs diagonally across the stipes and is inserted by a short flat tendon into the inner angle of the base of the lacinia.

The *Flexor of the Galea* (Fig. 15, fl.g.) is a smaller muscle having its origin in the outer integument of the stipes opposite the palpus and its insertion in the inner angle of the base of the galea.

Within the stipes there are two muscles which move the palpus. They both originate in the outer integument near the apodeme into which the flexor of the stipes is inserted. The proximal muscle is the *Extensor of the Palpus* (Fig. 15, ext.p.) and is inserted in the lateral edge of the base of the palpus. The second muscle, inserted at the opposite side of the base of the palpus is the *Flexor of the Palpus* (Fig. 15, fl.p.). Within each of the first three segments of the palpus there are an extensor and a flexor of the palpal segment. The *extensor* (Fig. 15, ext.p.s.) arises at the outer side of the base of the segment and the *flexor* (fl.p.s.) at the inner side. They are inserted respectively into the outer and inner sides of the base of the next distal segment.

THE LABIUM. The *Retractor of the Labium* (Figs. 16 and 17, r.lb.) is a long flat muscle with its plane at right angles to that of the labium. It originates in the base of the central plate of the tentorium near the inner angle of the postgena, and is inserted into the side of the ligula near the base of the paraglossa.

The *Abductor of the Labium* (Figs. 16 and 17, abd.lb.) is a straight parallel-fibered muscle. It originates from a small tubercle on the basal edge of the tentorium and is inserted at the outer angle of the distal edge of the mentum.

The *Adductor of the Labium* (Figs. 16 and 17, ad.lb.). The two adductors are contiguous at their origin near the middle of the base of the submentum, but diverge in their course. They are inserted by means of small semicircular tendons into the base of the ligula not far from the middle line.

The *Adductor of the Paraglossa* (Fig. 17, ad.pgl.) originates from the base of the ligula near the median line, and runs diagonally to the base of the distal segment of the paraglossa.

The *Adductor of the Glossa* (Fig. 17, ad.gl.) originates in the ligula and is inserted into the lateral side of the base of the glossa.

The musculature of the labial palpi is similar to that of the maxillary palpi, but the flexor and extensor arise from a narrow elongate, median apodeme (Figs. 6 and 17, ap.lb.) which is given off at the point where the labium and hypopharynx unite, and projects backward as far as the mentum.

THE HYPOPHARYNX. The *Depressors of the Hypopharynx* (Fig. 6, dep.hyp.) are two muscles which originate from the lower side of the central plate of the tentorium and are inserted into the upper integument of the base of the hypopharynx near the point at which the pharynx narrows into the oesophagus. The depression of the hypopharynx at this point assists in enlarging the oesophageal canal.

The *Elevator of the Hypopharynx* (Fig. 6, el.hyp.) originates in the face in front of the median ocellus, and is inserted on the outer surface of the hypopharynx near the entrance to the oesophagus. This muscle pulls the base of the hypopharynx up against the roof of the pharynx, closing the entrance to the oesophagus.

The *Compressor of the Hypopharynx* (Fig. 6, c.hyp.) originates with its fellow of the opposite side from the median line of the lower side of the hypopharynx at its junction with the labium. The two muscles diverge, running obliquely backwards and upwards, and are inserted into the outer angles of the upper side of the base of the hypopharynx in front of the oesophagus. By compressing the hypopharynx these muscles enlarge the pharyngeal opening.

The *Retractor of the Hypopharynx* (Fig. 6, r.hyp.) is a long flat muscle having its head contiguous to that of the retractor of the labium. It runs parallel to this muscle and is inserted into the side of the hypopharynx near the junction between this organ and the labium.

THE EPIPHARYNX. There is a single median epipharyngeal muscle (Fig. 9, eph.m.) which has the form of a truncated cone. Its points of attachment are the inner sides of the labium and epipharynx.

(b). *Muscles of the Antennæ.*

There are three muscles within the head which bring about the movements of the antenna as a whole. (Fig. 5, m.ant.)

The *Extensor of the Antenna* (Fig. 11, ext.ant.) originates from the dorsal side of the lateral angle of the anterior tentorial plate and is inserted into the lateral side of the base of the first antennal joint.

The *Flexor of the Antenna* (Fig. 11, fl.ant.) This muscle has its origin near the apical angle of the central tentorial plate in the angle formed by the anterior and posterior plates. It is inserted at the inner side of the basal margin of the first antennal segment.

The *Depressor of the Antenna* (Fig. 11, dep.ant.) has a very broad head attached to the dorsal side of the anterior arm of the tentorium and extending from the epicranium to the attachment of the anterior plate to the central plate. It tapers rapidly and is inserted into the ventral side of the basal segment of the antenna.

Within each antennal segment there is a *flexor* (Fig. 10, fl.a.s.) and an *extensor* (ext.a.s.) similar to those described in the palpi.

(c). *Muscles of the Pharynx and Oesophagus.*

The circular or constrictor muscles are well developed in the oesophagus. In addition to these there are several muscles originating in the wall of the head or the tentorium which function as dilators and suspensors of the pharynx and oesophagus.

The *Precerebral Dorsal Dilators* (Figs. 5 and 6, pr.d.) There are usually three paired dilator muscles lying in front of the brain. The *first* (pr.d.1) has its origin in the clypeus and is

inserted into the roof of the pharynx at a short distance from the median line. The *second* (pr.d.₂) originates in the front above the clypeus and is inserted into the pharynx behind the first. The *third dilator* (pr.d.₃) is inserted into the roof of the oesophagus just in front of the brain. Its origin is in the epicranium in front and to one side of the median ocellus. A fourth muscle is sometimes present.

The *Post-cerebral Dorsal Dilator* (Fig. 6, pst.d.) originates in the epicranium immediately in front of the adductor of the mandible and is inserted into the oesophagus just behind the brain and a short distance from the dorsal median line.

The *Lateral Dilator* (Fig. 5, l.d.) arises in the epicranium at the inner side of the compound eye and is inserted into the lateral median line of the oesophagus beneath the brain.

The *Ventral Dilators* (Fig. 6, v.d.) are two rows of small muscles which originate from the upper surface of the central plate of the tentorium and are inserted into the lower wall of the oesophagus a short distance on each side of the median line.

(d). *Cervical Muscles.*

(Figs. 18 and 19.)

The muscles which control the movements of the head may be classified as depressors, elevators, retractors and rotators of the head.

LONGITUDINAL MUSCLES.

(a) *Sternal.*

1. *The Inner Depressors of the Head* originate from the enlarged basal portions of the pro-entosternites and are inserted into the middle of the hind edge of the central tentorial plate. [137, 5th sternal muscle of the veracervix].

2. *The Outer Depressors of the Head* originate immediately laterad of the preceding, and are inserted into the dorsal surface of the central tentorial plate. [136, 4th sternal muscle of the veracervix].

3. *The Short Depressor of the Head*, origin, pro-entosternite, insertion, into the cervical membrane just beneath the ventral angle of the interpleurite. [135, 3rd sternal muscle of the veracervix].

(b) **Dorsal.**

4. *The Elevator of the Head.* A strong double intersegmental muscle. One head originates from the first intersegmental sclerite (Fig. 1, in.), the other from the posterior edge of the pronotum near the median line. The two are inserted by a common elongated tendon into the lateral apodeme (Fig. 2, AL.) of the dorsal border of the occipital foramen. [139, 140, 1st and 2nd tergal muscles of the veracervix].

(c) **Pleural.**

5. *The Retractor of the Head.* Origin, anterior edge of the pro-episternum; insertion, lateral side base of head. [138, Fifth (a) sternal muscle of the veracervix].

PLEURAL MUSCLES.

(a) **Noto-pleural.**

6. *The First Rotator of the Head.* Origin, anterior edge of the pro-episternum; insertion (1) median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen, and (2) anterior edge of the first intertergite. [141, 142, first and second external rotators of the head].

7. *The Second Rotator of the Head* originates from the anterior edge of the pronotum near the median line and is inserted into the postero-dorsal edge of the interpleurite near the dorsal angle. [143, the intersegmental muscle of the veracervix].

8. *The Third Rotator of the Head*, originates from the pronotum just in front of the distal end of the pleuron and is inserted into the ventral edge of the interpleurite. [144, second intersegmental muscle of the veracervix].

9, 10. *The Fourth and Fifth Rotators of the Head.* Both originate from the interpleurite and are inserted into the median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen. [146, 147, second and third dorsoventral muscles of the veracervix].

11. *The Sixth Rotator of the Head.* From the apodeme of the interpleurite to the lateral apodeme of the foraminal border. [148, fourth dorsoventral muscle of the veracervix].

12. *The Seventh Rotator of the Head.* Origin, apodeme of interpleurite; insertion, neck membrane behind the first intertergite. [145, first dorsoventral muscle of the veracervix].

(b) **Sterno-pleural.**

13. *The Cruciate Rotators of the Head*, originate from the anterior edge of the procoxae and are inserted into the narrow anterior portion of the interpleurite of the opposite sides. [134, the second sternal muscle of the veracervix].

Voss, ('05), regarding the cervical interpleurite as a sternal sclerite, describes 13 as a longitudinal sternal muscle, and 6 to 12 as dorsoventral muscles. I have followed Crampton ('17) in regarding the interpleurite as a pleural sclerite, in which case these muscles are sterno-pleural and noto-pleural respectively.

The several rotators working in pairs function as elevators and depressors.

III. MUSCLES OF THE THORAX.

A. *The Prothorax.*

LONGITUDINAL MUSCLES.

(a) **Sternal.**

XIII. *The First Prosternal Muscle* (Fig. 21) is a flat unpaired median muscle which originates in the posterior edge of the median entosternite spira of the prothorax, and is inserted into the anterior edge of the spira of the mesothorax. A retractor of the thorax. [102].

14, 14a. *The Second Prosternal* (Figs. 20 and 21). From the median entosternite, into the anterior side of the base of the coxa. A weak extensor of the coxa. [103].

15. *The Third Prosternal* (Fig. 20). From the prothoracic spira obliquely backwards into the distal section of the mesofurca. [104].

16. *The Fourth Prosternal* (Fig. 20). Origin, base of prothoracic furca; insertion, mesothoracic furca near 15. [105].

17. *The Sixth Prosternal* (Fig. 20). Origin, furca near 16; insertion, mesothoracic spira. [107].

18. *The Seventh Prosternal* (Fig. 20). From the spira into the base of the furca. [108].

The Longitudinal Prosternal muscles are retractors pulling the prosternite and mesosternite together and bending the head and prothorax downwards. The Longitudinal Pronotals are the antagonist muscles of the prosternals.

(b) Dorsal.

XIX. *The First Pronotal Muscle* (Fig. 20). From the posterior edge of the pronotum near the median line, into the inflexed posterior border of the neck membrane. [109].

19, 20. *The Third Pronotals* (Figs. 20, 21). From the first intersegmental sclerite into the median ridge of the pronotum. [111, 110].

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

21. *The Prothoracic Intersegmental Muscle*. From the base of the furca into the outer angle of the first intersegmental sclerite. Rotator of the thorax. [112].

(b) Noto-subcoxal.

22. *The First Dorsoventral Muscle of the Prothorax* (Fig. 20). From the pronotum immediately behind the distal end of the epimeron into the trochantin by a long flat tendon. A strong conical muscle. An extensor of the coxa.* [113].

(c) Noto-coxal.

23, 23a. *The Second Dorsoventral* (Fig. 20). Origin, in the pronotum immediately above the distal end of the pleuron usually with two (sometimes three) adjacent heads; insertion into the posterior edge of the coxa by a long thin tendon. A flexor of the coxa. [114].

24, 24a. *The Sixth Lateral* (Fig. 21). From the posterior side of the pronotum into the latero-caudal edge of the coxa by a broad tendon. Two heads—24 is a stout-bellied muscle while 24a is quite slender. Flexor of the coxa. [121].

(d) Noto-trochanteric.

25, 25a-25e are the six heads of a complex muscle inserted by a common tendon into the inner angle of the base of the trochanter. Together they form the extensor of the femur. The origins of the various heads are noted in their proper places below.

* When the coxa is pulled backwards it moves upwards towards the sternum. A forward pull moves it also downwards away from the body. I have designated the muscles which bring about these motions as *flexors* and *extensors* respectively, reserving the terms *adductor* and *abductor* for those muscles which pull the coxae inwards towards each other and outwards away from each other.

25b. *The Sixth (a) Lateral* (Fig. 21) originates from the lateral anterior edge of the pronotum. This muscle takes a sharp bend, passing between the pronotum and the pleuron, and enters the coxal cavity on the posterior side of the entosternite. [122].

25d. *The Eighth Dorsoventral* (Figs. 20, 21) originates in the dorso-lateral portion of the pronotum just behind the posterior edge of the epimeron. [117].

PLEURAL MUSCLES.

(a) *Pleuro-pedal.*

25. *The Fourth Lateral* (Fig. 20). Origin, the distal anterior edge of the inner face of the episternum. [119].

25a. *The Fifth Dorsoventral* (Figs. 20, 21) originates from the inner face of the epimeron. [115].

25c. This is a short muscle originating in the epimeron, near the ventral end, quite close to the leg. At its point of attachment it is pressed closely between the epimeron and the distal blade of the entosternite.

25e. This also is a very short muscle originating in the outer face of the entopleurite opposite the origin of 25c. (Not figured).

26. *The Fourth Lateral* (Fig. 21). Origin, from the episternum, by a curved head bending round the distal end of the entopleurite; insertion, by tendon into the latero-anterior edge of the coxa. Extensor of the coxa. [118].

27. *The Fifth Lateral* (Fig. 21). From the inner face of the episternum near its attachment to the ventral edge of the pronotum, into the lateral angle of the trochantin. [?120].

(b) *Noto-pleural.*

XXVIII. *The Dorsoventral Muscle* (not figured), is a very short, but strong muscle binding the pleuron closely to the pronotum.

(c) *Sterno-pleural.*

XXIX. *The Furca-entopleural Muscle* (not figured), also very short, binds the distal portion of the furca to the entopleurite. [132].

STERNAL MUSCLES.

(a) **Sterno-pedal.**

28. *The First Pedal Muscle of the Prothorax* (Fig. 21). From the base of the furca into the anterior border of the coxa. Extensor of coxa. [127].

29. *The Second Pedal Muscle* (Fig. 20). From the furca near its base into the posterior border of the coxa. Flexor of the coxa. [128].

30. *The Third Pedal Muscle* (Fig. 21). From the furca above the leg cavity into the meso-caudal edge of the coxa. An adductor and flexor of the coxa. [129].

31. *The Seventh Pedal Muscle* (Fig. 21). From the spira into the posterior border of the coxa. Probably a weak flexor or rotator, but of little functional importance. [131].

B. *The Mesothorax.*

LONGITUDINAL MUSCLES.

(a) **Sternal.**

32. *The Second Mesosternal Muscle* (Fig. 21). Homologue of 14. [66].

33. *The Third Mesosternal* (Fig. 20). Homologue of 15. [67].

34. *The Fourth Prosternal* (Fig. 20). Homologue of 16. [68].

(b) **Dorsal.**

35. *The First Mesonotal Muscle* (Fig. 21). A broad flat muscle near the dorsal median line originating from the entotergite of the metathorax and inserted into the anterior border of the mesoscutum. This and the next are retractors of the thorax drawing the meso- and meta-tergites together. [69].

36. *The Second Mesonotal* (Fig. 20). Similar to 35 in origin, but inserted into the first intersegmental sclerite. Lies on the inner (ventral) side of 35. [70].

XXXVI. *The Third Mesonotal* (Fig. 21). An oblique muscle running from the second intersegmental sclerite to the mesoscutellum. [71].

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

37. *The Mesothoracic Intersegmental Muscle* (Fig. 20). Homologue of 21. [73].

45. *The Seventh Dorsoventral Muscle of the Mesothorax* (Fig. 21 B). Origin, precoxale; insertion anterior notal wing process. Present only in the male and long winged female. Elevator of the tegmen. [78].

(b) Noto-coxal.

38, 38a. *The First and Sixth Dorsoventrals* (Fig. 20). Origin, by two heads from the lateral side of the anterior border of the mesoscutum; insertion by a common tendon into the anterior border of the coxa. The inner belly (38) is broad and stout with parallel fibres, the outer (38a) is slender and conical. The tendon is broad at its base, narrowing into a long linear process. The insertion of 38 is at the broad base of the tendon, that of 38a at the apex of the narrow process (cf. the homologous muscle 59, 59a, Fig. 31). Because of their insertion by a common tendon I have described this muscle and the two following as single muscles. Extensor of the coxa; indirect elevator of the tegmen. [74, 77].

39, 39a. *The Third and Fourth Dorsoventrals* (Fig. 20). The inner head (39) originates in the scutum, not very far from the median line, the outer (39a) near the postero-lateral edge of the scutum above the posterior notal wing process. The tendon, inserted into the posterior side of the coxa, is bilobed, one lobe being broad and short and the other narrow spatulate. 39, a broad, parallel-fibred belly, is attached to the broader lobe, while 39a, a narrow conical belly, is attached to the elongated lobe (cf. 60, 60a, Fig. 30). Voss describes the homologous metathoracic muscles, but states that these muscles are absent in the mesothorax of *Gryllus domesticus*. On the other hand, I have been unable to find his second dorsoventral muscle either in the mesothorax or metathorax of *G. assimilis*. Flexor of the coxa.

(c) Noto-trochanteric.

40, (40a). *The Fifth Dorsoventral and the Third Lateral* (Fig. 20). 40 arises in the mesoscutum just laterad of the origin of 39; 40a is a pleuro-pedal muscle originating in the

mesothoracic basalar sclerite. The two bellies enter the coxal cavity where they unite in a common broad flat tendon by which they are inserted into the upper anterior edge of the trochanter. Extensors of the femur; 40a is also an elevator of the tegmen. [76, 81].

PLEURAL MUSCLES.

(a) Pleuro-pedal.

41. *The First (and Second) Lateral Muscle of the Mesothorax* (Fig. 21). From the trochantin by tendon into the basalar sclerite. Usually biceps or digastric. Elevator of the tegmen, also elevator of the coxa. [79, 80].

40a. *The Third Lateral*. See above. [81].

42. *The Fourth Lateral* (Fig. 21). From the upper edge of the mesepisternum, by tendon into the latero-anterior side of the coxa. Extensor of the coxa. [82].

43. *The Fifth Lateral* (Fig. 22). From the episternum near its middle, into (1) the anterior edge of the coxa, (2) the trochantin, and (3) the precoxale. Extensor of the coxa. [83].

44. *The Sixth Lateral* (Fig. 21). From the postero-lateral edge of the coxa into the subalar plate. Depressor of the tegmen. Flexor of the coxa. [84].

45. (See Tergo-sternals above).

46. (See Sterno-pleurals below).

(b) Noto-pleural.

47. *The Eleventh Lateral Muscle* (Fig. 21). From the anterior side of the pleural wing process into the first inter-segmental sclerite. Probably an elevator of the tegmen. [88].

48. *The Twelfth Lateral Muscle* (Fig. 21). From the posterior side of the pleural wing process into a wing axillary just above the subalar plate. A short strong muscle. Depressor of the tegmen. [89].

49. *The Ninth Lateral Muscle* (Fig. 21). From the posterior face of the entopleurite ventrad of the origin of 48, into the posterior notal wing process. A depressor of the tegmen. [86].

(c) Sterno-pleural.

51. *The Lateral Adductor of the Mesothorax* (Fig. 20). From the median entosternite into a small pleural intersegmental sclerite behind the second spiracle. [101].

46. *The Fourteenth Lateral Muscle* (Fig. 21 B). From the precoxale into the basalar sclerite by the same tendon as 38. Found only in the male. Elevator of the tegmen. [91].

LI. *The Furca-entopleural Muscle* (not figured). From the inner sides of the entosternal pocket into the ventral process of the entopleurite. Binds the two processes together. [100].

STERNAL MUSCLES.

Sterno-pedal.

52. *The First Pedal Muscle of the Mesothorax* (Fig. 21). Origin, by three heads from (1) the base of the entosternite, (2 and 3), the sternum immediately in front of the entosternite; insertion into the anterior edge of the coxa. Extensor of the coxa. [93].

LII. *The Seventh Pedal Muscle* (Fig. 21). From the median entosternite, into the posterior edge of the coxa. Flexor of the coxa. [99].

53. *The Second Pedal Muscle* (Fig. 20). From the lateral entosternite above the inner angle of the leg into the posterior edge of the leg adjacent to the insertion of 39. Flexor of the coxa. [94].

54. *The Third Pedal Muscle* (Fig. 21). From the posterior edge of the entosternal pocket into the meso-caudal side of the edge of the coxa. Flexor and adductor of the coxa. [95].

55. *The Fifth Pedal Muscle* (Fig. 21). From the posterior edge of the distal end of the entosternite into the postero-lateral border of the coxa. Adductor of the coxa. [97].

LV. *The Fourth Pedal Muscle* (Fig. 21 B). From the entosternite near the origin of 54, into the trochanter by the same tendon as 40. Extensor of the femur. [96].

C. The Metathorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

LVI. *The First Metasternal Muscle* (Figs. 20 and 32). Originates from the posterior side of the base of the entosternite near the median line and runs backwards above the first four abdominal sternites. It has three insertions into the lateral end of the anterior edge of the third, fourth and fifth sternites respectively. A ventral retractor of the abdomen. [34].

LVII, LVIIa. *The Second and Third Metasternal Muscles* (Figs. 20 and 32). From the posterior side of the base of the entosternite into the parasternal plate. Depressor of the abdomen. [35].

56. *The Fourth Metasternal* (Fig. 20). From the posterior side of the entosternal pocket, into the parasternal plate. Retractor of the sternum. [36].

(b) **Dorsal.**

57. *The First Metanotal Muscle* (Fig. 20). From the anterior edge of the first abdominal tergite into the entotergite of the metascutum. Parallel and adjacent to the median line. In the long-winged female this muscle is often very strongly developed. (Fig. 28). [37].

DORSOVENTRAL MUSCLES.

(a) **Tergo-sternals.**

58. *The Metathoracic Intersegmental Muscle* (Fig. 20). From the distal end of the entosternite into the first abdominal tergite between the first and second dorsal longitudinal muscles. Homologue of 21 and 37. Rotator of the thorax. [41].

(b) **Noto-coxal.**

59, 59a. *The First and Sixth Dorsoventral Muscles of the Metathorax* (Figs. 20 and 31). Extensors of the coxa. Homologues of 38 and 38a, q. v. [42, 47].

60, 60a. *The Third and Fourth Dorsoventrals* (Figs. 20 and 30). Flexors of the coxa. Homologues of 39, 39a, q. v. [44, 45].

(c) **Noto-trochanteric.**

61, (61a). *The Fifth Dorsoventral and the Third Lateral* (Figs. 20 and 29). Extensors of the femur. See 40, 40a. [46, 50].

PLEURAL MUSCLES.

(a) **Pleuro-pedal.**

61a. See above. [50].

62. *The First and Second Lateral Muscles of the Metathorax* (Fig. 21). See 41. Elevator of wing. [48, 49].

63. *The Fourth Lateral* (Fig. 21). Homologue of 42 q. v. [51].

64. *The Fifth Lateral* (cf. Fig. 22). The Homologue of 43. The precoxale is not developed as a separate sclerite in the metathorax, so this muscle has but two insertions, into the trochantin and the coxa. [52].

65. *The Sixth Lateral* (Fig. 21). Homologue of 44. This muscle is inserted quite distinctly into the coxa and not into the epimeron as is the case in *G. domesticus* (Voss). Depressor of the wing. [53].

(b) **Noto-pleural.**

66. *The Seventh Lateral* (Fig. 21). Origin, from the epimeron, a short distance dorsad of its middle; insertion, into the posterior subalar plate. Depressor of the wing. [54].

67. *The Twelfth Lateral* (Fig. 21). The homologue of 48 q. v.

68. *The Eleventh Lateral* (Fig. 21). From the anterior side of the pleural wing process into the anterior angle of the base of the wing; just in front of the anterior notal wing process. Elevator of the wing. [58].

(c) **Sterno-pleural.**

LXVIII. *The Furca-entopleural Muscle of the Metathorax* (Not figured). Homologue of LI, q. v.

STERNAL MUSCLES.

Sterno-pedal.

69. *The First Pedal Muscle of the Metathorax* (Fig. 20). From the anterior side of the base of the entosternite into the inner anterior edge of the coxa. Adductor and extensor of the coxa. [60].

70. *The Second Pedal Muscle* (Fig. 20). Homologue of 53, q. v. [61].

71. *The Third Pedal Muscle* (Fig. 21). Homologue of 54. [62].

72. *The Fifth Pedal Muscle* (Fig. 21). Homologue of 55. [64].

LXXII. *The Fourth Pedal Muscle* (Not figured, cf. Fig. 21B, LV). Homologue of LV.

THE MUSCLES OF THE LEGS.

(Plate V.)

The various muscles of the coxa as well as the large extensors of the femur which originate in the thorax have already been described. The following muscles lie entirely within the leg segments.

(a) **Coxo-trochanteric Muscles.**

The First Intracoxal Extensor of the Femur (Figs. 23 and 25, 1 ext. fem.) is a stout muscle with slightly converging fibres. It originates from the anterior side of the basal border of the coxa and is inserted into the trochanter just in front of the insertion of the large noto-trochanteric extensors.

The Second Intracoxal Extensor of the Femur (Figs. 23 and 25, 2 ext. fem.) is a conical muscle originating from the ventral edge of the base of the coxa and inserted by the same tendon as the noto-trochanteric extensors into the ventral edge of the trochanter.

The Third Intracoxal Extensor of the Femur (Figs. 23 and 26, 3 ext. fem.) originates from the posterior face of the coxa and is inserted into the trochanter behind the insertion of the noto-trochanteric extensor.

The First Flexor of the Femur (Figs. 23 and 26, 1 fl. fem.) originates in the dorsal edge of the coxa, and in the first and second legs, is inserted by a tendon into the dorsal edge of the base of the trochanter. In the hind legs it is inserted into the base of the femur at the dorsal edge of the femoral opening.

The Second Flexor of the Femur (Figs. 24 and 26, 2 fl. fem.) is similar to the first in its insertion. In the pro- and mesothoracic legs this flexor is a simple conical muscle, originating from the ventral side of the basal end of the coxa and running diagonally across the coxa. In the metathoracic leg the second flexor is a more powerful multiceps muscle. One head originates from the posterior face of the coxa, one from the ventral edge of the anterior face, and three from the basal edge of the anterior face.

(b) **Trochantero-femoral Muscles.**

The Fourth Extensor of the Femur (Fig. 25, 4 ext. fem.) is a small muscle originating from the ventral side of the base of the trochanter and inserted into the ventral side of the base of the femur.

The Anterior Flexor of the Femur (Fig. 26, ant. fl.) is a broad flat muscle with parallel fibres. It originates from the basal edge of the anterior face of the trochanter and is inserted into the anterior face of the femur. These two muscles are not present in the small trochanter of the hind legs.

(c) **Femoro-tibial Muscles.**

The Extensor of the Tibia (Figs. 23 and 25, ext. tib.) In the large leaping hind leg this muscle originates from the entire dorsal two-thirds of the inner surface of the femur. It is a pseudo-penniform muscle sending short oblique fibres into the long spatulate tendon by which it is inserted into the dorsal edge of the base of the tibia.

In the first and second legs (Fig. 25, ext. tib.) the extensor is much weaker. The tendon is shorter and the fibres originate chiefly from the basal end of the femur, though some spring from near or beyond the middle of the segment.

The Flexor of the Tibia (Figs. 23 and 25, fl. tib.) originates by two heads from (1) the ventral side of the base of the trochanter and (2) the proximal end of the ventral side of the femur. It is a conical muscle and is inserted into the ventral proximal edge of the tibia by means of a long linear tendon.

(c) **Tibio-tarsal Muscles.**

The First Extensor of the Tarsus (Fig. 23, 1 ext. tar.) is very similar to the extensor of the tibia in the hind leg. It lies in the ventral half of the tibia, and is inserted into the proximal end of the first tarsal segment.

The Second Extensor of the Tarsus (Fig. 23, 2 ext. tar.) originates from the dorsal side of the tibia near the femoro-tibial articulation. It is a short conical muscle and is inserted by a long filamentous tendon, running through the greater part of the tibia and tarsus, into the ventral edge of the third tarsal segment.

The second tarsal segment, projecting as it does backwards and forwards beneath the first and third, limits the flexing of the tarsal segments, so that this muscle extends the entire tarsus outwards in a straight line with the tibia.

The Flexor of the Tarsus (Fig. 23, fl. tar.) originates in the dorsal face of the tibia a short distance from the articulation with the femur. It is inserted by a flat tendon into the first tarsal segment.

(d) **Tarsal Muscles.**

The Extensor of the Second and Third Tarsal Segments (Fig. 23, ext. tar.₂) lies in the dorsal side of the first tarsal segment. It originates in the proximal end of the segment and is inserted into the dorsal proximal edge of the second segment. When this last is extended it pulls the third segment with it so that the two segments move together.

The Extensor of the Claws (Fig. 23, ext. ung.) originates from the proximal end of the dorsal side of the third tarsal segment and is inserted into the base of the claws by means of a tendon, which forms a bridge between them on the dorsal side.

The Flexor of the Claws (Figs. 23 and 27, fl. ung.) originates on the ventral side of the third segment opposite the origin of the extensor. Connected with the base of the claws on the ventral side is a prominent apodeme (Fig. 27, ap. ung.) at the end of which the flexor is inserted by a long narrow tendon.

IV. MUSCLES OF THE ABDOMEN.

(Plate VI, Figs. 32-36.)

A. First Abdominal Segment.

LONGITUDINAL MUSCLES.

(a) **Sternal.**

73. *The First Ventral Muscle* (Fig. 32). From near the antero-lateral edge of the first sternite, into the anterior edge of the second sternite. [26].

74. *The Second Ventral* (Fig. 32). From the lateral side of the first sternite into the inner angle of the parasternal plate. [27].

(b) **Tergal.**

75. *The First Dorsal Muscle* (Fig. 32). Two straight flat muscles lying in the tergum near the median line. They originate from the posterior edge of the tergite and are inserted into the anterior edge of the second tergite. [28].

76. *The Second Dorsals* (Fig. 32). Origin contiguous to that of 75; inserted into the lateral end of the anterior edge of the second tergite. [29].

The longitudinal muscles are retractor muscles of the abdomen.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

77. *The Second Dorsoventral* (Fig. 32). From the lateral edge of the tergite near the posterior end, into the lateral angle of the parasternal plate. [31].

PLEURAL MUSCLES.

Sterno-pleural.

78. *The Dilator of the Spiracle* (Fig. 32). From the lateral end of the anterior edge of the parasternal plate into the closing lever or process of the stigmatal bow. [32, Lateral stigmatal muscle α].

79. *The Second Dilator of the Spiracle* (Fig. 32) originates with 78 from the parasternal plate and is inserted into the pleural membrane just behind the spiracle. Present only in the first and second abdominal segments. [32, Lateral stigmatal muscle β].

B. The Second Abdominal Segment.

TRANSVERSE MUSCLES.

Sternal.

80. *The Ventral Transverse Muscle* (Fig. 32). From the middle of the parasternal plate of one side across the anterior end of the second sternite into the parasternal plate of the other side. [17].

LONGITUDINAL MUSCLES.

(a) Sternal.

81. *The First Ventral Muscle* (Fig. 32). From behind the anterior margin of the second sternite into the anterior margin of the third sternite. [13].

82. *The Second Ventral Muscle* (Fig. 32). From the mesal edge of the parasternal plate, into the anterior edge of the third sternite. [14].

(b) Tergal.

83. *The First Dorsal Muscles* (Fig. 32). Homologous with 75 and similarly arranged.

84. *The Second Dorsal Muscles* (Fig. 32). Homologous with 76, but originate near the transverse medial line and not in the anterior margin of the second tergite.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

85. *The First Dorsoventral Muscle* (Fig. 32). From the anterior end of the lateral edge of the tergite into the parasternal plate immediately behind the insertion of the tergo-sternal of the first segment. [30].

As stated before, the musculature of the parasternal plate indicates that this sclerite is composed of detached portions of the first and second sternites. Muscles 56, LVII, 74, 77, 78 and 79 appear to belong to the first sternite, while the others belong to the second. Voss, however, described 85 as an inter-segmental muscle, a mistake no doubt due to the fact that the anterior tergo-sternals not being developed in any other segment in *G. domesticus*, he failed to trace the homology.

86. *The Second Dorsoventral* (Fig. 32). A straight parallel-fibred muscle originating from the posterior end of the lateral edge of the tergite and inserted into the corresponding region of the sternite. [18].

PLEURAL MUSCLES.

(a) Noto-pleural.

87. *The Fourth Lateral Muscle* (Fig. 32). From the postero-lateral angle of the tergite into the posterior pleural sclerite of the second segment. [22].

88. *The Fifth Lateral Muscle* (Fig. 32). Origin as in 87; insertion into the first pleural sclerite of the third segment. [23].

(b) Sterno-pleural.

89. *The First Lateral Muscle* (Fig. 32). From the parasternal plate into the pleural membrane in front of the spiracle. Voss regards this as the first and second laterals. The large third pleural sclerite (ps_3) of the third segment probably results from the fusion and enlargement of the sclerites of the second and third segments, in which case 92 is probably the homologue of the second lateral of the succeeding segments and I have thus regarded it. [19, 20].

90, 91. *The Dilators of the Spiracles* (Fig. 32). Homologues of 78 and 79, and similarly placed. [25, lateral stigmatal α and β].

92. *The Second Lateral* (Fig. 32). From the parasternal plate into the antero-ventral edge of the third pleural sclerite of the third segment. [24, sixth lateral parastigmatal].

93. *The Third Lateral* (Fig. 32). From the parasternite into the second pleural sclerite of the second segment.

*C. The Third to Sixth Segments of the Female;
Third to Eighth of the Male.*

TRANSVERSE MUSCLES.

Sternal.

94. *The Transverse Ventral Muscle* (Fig. 32) lies entirely within the sternum across the anterior end. Its points of attachment are near the latero-anterior angles of the sternite.

LONGITUDINAL MUSCLES.

(a) **Sternal.**

95. *The First Ventral Muscle* (Fig. 32). A short muscle having its origin near the transverse median line and lying not far from the longitudinal median line of the sternite. It is inserted into the anterior border of the segment behind the one in which it lies. [1].

96. *The Second Ventral Muscle* (Fig. 32) lies in the lateral side of the sternum and extends from the anterior border of one segment to the anterior border of the next segment behind. [2].

(b) **Dorsal.**

83, 84. *The First and Second Dorsals.* (See above).

DORSOVENTRAL MUSCLES.

Tergo-sternal.

97. *The First Dorsoventral Muscle* (Fig. 32) stretches across the pleural membrane from the antero-lateral angle of the tergite to the corresponding region of the sternite. Homologue of 85.

98. *The Dorsoventral Sternal* (Fig. 32). Homologue of 77 and 86. Similar to 97, but lying in the posterior end of the segment. [5].

PLEURAL MUSCLES.

(a) Noto-pleural.

99. *The Fourth Lateral Muscle*. Homologue of 87, q. v. [9].

100. *The Fifth Lateral*. Homologue of 88, q. v. [10].

(b) Sterno-pleural.

The sternopleural muscles (101 to 105) all originate from the lateral border of the sternite in succession from the anterior to the posterior end of the sclerite. They are inserted into the pleural sclerites or into the spiracle, as follows:

101. *The First Lateral*, into the first pleural sclerite. [6].

102. *The Second Lateral*, into the third pleural sclerite. [7].

103. *The Dilator of the Spiracle*, into the process of the bow of the spiracle. [11].

104. *The Third Lateral*, into the second pleural sclerite. [8].

105. *The Third (a) Lateral*, with 104 into the second pleural sclerite.

Functions of the Foregoing Abdominal Muscles. The longitudinal muscles are retractors of the abdomen. The ventral and dorsal working together telescope the segments. The ventral bend the body downwards, while the dorsal act as their antagonist muscles, bending the body upwards. The tergo-sternals and laterals are expiratory muscles, and pull the sternum and tergum together. Those of either side working alone may act as rotators of the abdomen.

THE EXTREMITY OF THE ABDOMEN.

In both sexes ten dorsal segments, including the suranal plate (Figs. 3, 33, 35, P. S.) can be readily distinguished. On the ventral side, however, there are only eight in the female and nine in the male, including the subgenital plate. A study of the musculature as described below will show, apart from other evidence, that in the female the supra-genital plate, lying above the ovipositor is the sternite of the ninth segment, and in both sexes the podical plates (P. P.) are the divided halves of the tenth sternite.

D. The Seventh Abdominal Segment of the Female.

LONGITUDINAL MUSCLES.

Sternal.

106. *The Retractor of the Vagina* (Fig. 33) is a flat parallel-fibred muscle originating from the antero-lateral angle of the seventh sternite and inserted into the dorsal side of the vagina at its junction with the oviduct. A suspensor and retractor of the vagina. The muscle probably helps to force the egg out by elongating the vagina, thus reducing its lumen and exerting pressure on the egg.

107. *The Adductor of the Subgenital Plate* (Figs. 33 and 34). A rectus muscle having its origin adjacent to and immediately in front of 106. It is inserted into the lateral end of the anterior border of the eighth sternite or subgenital plate. Homologous with the second sternals.

The other muscles are similar to those of the preceding segments.

E. The Eighth Segment in the Female.

LONGITUDINAL MUSCLES.

(Fig. 34.)

There are no longitudinal muscles in the eighth sternites. The tergal muscles occupy the entire tergum except the median line, and all extend from the anterior to the posterior border, showing no differentiation between the first and second dorsals.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

108. *The Abductor of the Subgenital Plate* (Fig. 34) originates from the lateral end of the anterior process of the eighth tergite, runs obliquely ventrad, and is inserted into the antero-lateral angle of the subgenital plate.

(b) Noto-gonapophysal.

109. *The First Depressor of the Ovipositor* (Fig. 33) is a large, strong, conical muscle originating from the inner face of the anterior process of the eighth tergite and running obliquely ventrad to be inserted into the ventral process of the ventral gonapophysis.

F. The Ninth Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

110. *The Second Ventral* (Fig. 35). A rectus muscle from the anterior lateral angle of the subgenital plate, the ninth sternite, into the ventral edge of the podical plate or tenth tergite. This muscle apparently enlarges the anal opening. Found in the male only.

(b) Tergal.

Similar to the eighth segment.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

111. *The Indirect Elevator of the Ovipositor* (Fig. 34). A straight muscle from the anterior edge of the ninth tergite into the supragenital plate or ninth sternite.

(b) Noto-gonapophysal.

112. *The Second Depressor of the Ovipositor* (Figs. 33 and 34), is a strong muscle originating from the entotergite of the ninth segment. It is inserted into (1) the ventral process of the dorsal gonapophysis and (2) the median process of the transverse beam connecting the ventral processes of the two dorsal gonapophyses.

113. *The Third Depressor of the Ovipositor* (Fig. 33), a stout, conical muscle, also originates from the inner face of the anterior process (entotergite) of the ninth tergite. It lies on the inner side of the second depressor and is inserted into the ventral process of the dorsal gonapophysis.

114. *The First Elevator of the Ovipositor* (Figs. 33 and 34), is a short broad muscle originating from the lateral anterior edge of the ninth tergite and inserted into the ventral face of the dorsal process of the dorsal gonapophysis.

STERNAL MUSCLES.

(a) Male Genital Muscles.

115. *The Suspensory Muscle of the Spermatophore Cup* (Figs. 35 and 36), a short muscle from the latero-anterior angle of the subgenital plate into the ventral valve of the spermatophore cup at its junction with the ductus ejaculatorius.

116. *The First Retractor of the Spermatophore Cup* (Figs. 35 and 36) originates from the anterior end of the ventral valve at its junction with the ductus, runs obliquely round the cup and is inserted into the lateral side of the dorsal valve at the posterior end where the chitinous plates are given off.

117. *The Second Retractor of the Spermatophore Cup* (Figs. 35 and 36) is similar to the first retractor in origin and insertion and lies between it and the cup.

118. *The Dilator of the Mouth of the Spermatophore Cup* (Figs. 35 and 36), a very short, straight muscle having its origin on the dorsal side of the dorsal valve and its insertion adjacent to that of the retractors.

119. *The Constrictor of the Spermatophore Cup* (Figs. 35 and 36) forms a muscular tunic covering the outer surface of the dorsal valve of the spermatophore cup. The action of this muscle and of the retractors forces the spermatophore out of the cup.

(b) Female Genital Muscles.

120. *The Protractor of the Ovipositor* (Fig. 33) is a short, stout muscle which originates from the process of the supragenital plate (P. S. G.) and is inserted into the inner face of the ventral process of the dorsal gonapophysis. Pulls the ovipositor backwards.

121. *The Lateral Abductor of the Gonapophyses* (Fig. 33) also originates from the supragenital process and is inserted into the dorsal process of the ventral gonapophysis. It pulls the two gonapophyses of one side apart from those of the other side, at the same time enlarging the genital orifice which lies between the bases of the ventral gonapophyses. It also elevates the ovipositor.

THE MECHANICS OF THE OVIPOSITOR.

The two plates on each side are enabled to work together (1) by a tongue and groove joint which runs along their entire length and (2) by the interlocking of the dorsal processes. (Fig. 3).

The ovipositor is a lever of the first order, the inner processes being the force arms, so that an upward or downward pull on these processes, respectively depresses or elevates the external plates. Similarly an inward pull (the transverse beam being the fulcrum in this case) separates the right and left plates externally.

G. The Tenth Segment.

LONGITUDINAL MUSCLES.

(a) **Sternal.**

122. *The Ventral Muscle* (Fig. 35) is a short flat muscle lying across the inner end of the pedical plate. Probably the homologue of the first ventral muscle of the anterior segments.

(b) **Tergal.**

123. *The Dorsal Muscle* (Fig. 35), a homologue of the first dorsals of the anterior segment lies near the median line of the suranal plate, stretching from the anterior to the posterior borders of the sclerite. This and the preceding pull the edges of the anus forward, probably aiding in the ejection of the faeces.

DORSOVENTRAL MUSCLES.

(a) **Tergo-sternal.**

124. *The First Dorsoventral* (Fig. 35). From the lateral side of the anterior edge of the suranal plate into the anterior edge of the podical plate near the insertion of the first ventral of the ninth segment. Pulls down the podical plate, enlarging the anal orifice.

125. *The Second Dorsoventral* (Fig. 35). From near the hinder end of the suranal plate into the podical plate a short distance in front of its hinder border. Closes the anal orifice by bringing the edges of the suranal and podical plates together.

(b) **Noto-cercal.**

126. *The Adductor of the Cercus* (Figs. 34 and 35). From the median line of the suranal plate into the inner side of the base of the cercus.

127. *The Depressor of the Cercus* (Figs. 34 and 35). From the anterior edge of the suranal plate into the ventral side of the base of the cercus.

128. *The Elevator of the Cercus* (Figs. 34 and 35) originates laterad of the origin of the depressor and is inserted into the dorsal edge of the cercus.

129. *The Abductor of the Cercus* (Figs. 34 and 35). From the anterior edge of the lateral portion of the suranal plate into the outer edge of the cercus.

V. THE MUSCLES OF THE SPIRACLES.

THE MESOTHORACIC SPIRACLE (Fig. 37) lies transversely in the pleural membrane behind the prothoracic leg. The anterior lip is composed of a broad ventral (a. l.₁) and a narrow dorsal (a. l.₂) sclerite. Two tracheal chambers open into the vestibule and between the two chambers there is a thickened chitinous septum (c. t.)

The First Occlusor of the Mesothoracic Spiracle (Fig. 37, oc.₁ sp.) originates near the anterior margin of the episternum of the mesothorax and is inserted into the ventral anterior valve. It closes the orifice of the spiracle by pulling the anterior lip against the posterior.

The Second Occlusor of the Mesothoracic Spiracle (Fig. 37, oc.₂ sp.) originates from the ventral sclerite of the anterior lip and is inserted into the anterior side of the chitinous septum between the two tracheal chambers. It closes the dorsal chamber by pulling its anterior and posterior walls together. There seems to be no mechanism for closing the ventral chamber apart from the first occlusor.

THE METATHORACIC SPIRACLE (Figs. 38 and 39) has a crescent shaped anterior lip (a. l.) and a somewhat sickle-shaped posterior lip (p. l.) with an expanded ventral end. There is but one tracheal chamber, the ventral wall of which has a chitinous thickening which serves for the insertion of an occlusor muscle.

The First Occlusor of the Metathoracic Spiracle (Fig. 38, oc.₁ sp.) originates from the outer border of the posterior lip and is inserted into the anterior lip. It closes the spiracle by pulling the two valves together.

The Second Occlusor of the Metathoracic Spiracle (Fig. 39, oc.₂ sp.) has the same origin as the first, but is inserted into the chitinous thickening of the wall of the tracheal chamber. It closes the chamber by pulling its walls together.

THE ABDOMINAL SPIRACLES (Figs. 40 and 41) have a triangular posterior valve and an arcuate anterior valve. Each valve bears a narrow ridge beset with minute chitinous projections. The ridge of the anterior segment is the "bow" of Landois, and bears near its ventral end an inward projecting process, the closing lever or peg.

The Occluser of the Abdominal Spiracles (Figs. 40 and 41, oc. sp.) is a short muscle which takes its origin from the dorso-posterior edge of the triangular posterior valve. It is inserted into the process of the bow and closes the spiracle by pulling the bow down against the other lip.

The Dilator Muscle (Figs. 40 and 41, d. sp., Fig. 32, 103) originates from the lateral edge of the abdominal sternite and is inserted into the extreme ventral end of the closing lever.

VI. THE MUSCLES OF THE VISCERA.

The Constrictor Muscles of the Oesophagus and Crop form a muscular tunic composed of a single layer of circular muscles.

The Constrictor Muscles of the Proventriculus (Fig. 42, c. m.) form a very strong muscular coat consisting in its thickest part of as many as ten layers of circular muscles.

The Dilator Muscles of the Proventriculus (Fig. 42, d. m.) are situated within the cavity of each median tooth. The edges are attached at the bases of the outer barbated lobes near the partitions between the epithelial folds. The muscle folds on itself, the fold extending far within the cavity of the median tooth. The effect of the contraction of this peculiar muscle is to pull the epithelial folds outwards towards the muscular tunic, thus enlarging the lumen of the proventriculus.

The Constrictors of the Mesenteron form a single layer of circular muscles.

The Dilators of the Mesenteron are longitudinal muscles, several groups of which lie along this organ outside the circular muscles.

The Constrictors of the Rectum (Figs. 43 and 44, c. m.) are usually two layers thick.

The Dilators of the Rectum (Figs. 43 and 44, d. m.) There are six groups of dilator muscles in the rectum, which originate from the body wall as follows: The two dorsals from the anterior edge of the tenth tergite, one on each side of the median line; the two laterals from the lateral side of the anterior edge of the same sclerite, in front of the cerci; the two ventrals in the male from the latero-anterior processes of the eighth sternite, in the female from the base of the ventral gonapophyses in the angle between the ventral and dorsal processes. Each of these groups

enters the rectum, behind its middle, on the line where the primary epithelial folds are in contact with the muscular tunic. The muscles of each group then separate, running backwards and forwards along this line and extending from the anus to the junction of the colon and rectum.

The Suspensorium of the Crop and Gastric Caecum is a thin muscle originating from the anterior border of the pronotum near the median line. One branch enters the latero-dorsal wall of the crop near its middle and runs backwards towards the pro-ventriculus; another branch is inserted at the apex of the caecum and divides into several smaller bundles which run backwards, forming the longitudinal muscles of the caecum.

The Alary Muscles of the Heart. There are ten of these delicate fan-shaped muscles, one in the mesothorax, one in the metathorax, and one in each of the eight anterior abdominal segments. They originate in the dorsal diaphragm near the median line beneath the heart, and are inserted near the lateral end of the anterior border of the several tergites.

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REFERENCE LETTERING.

- A₁, A₂, etc.—Abdominal segments.
 Abd.—Abductor muscle.
 Ad.—Adductor Muscle.
 A. L.—Lateral apodeme of the dorsal border of the occipital foramen.
 a. l.—Anterior valve of the spiracle.
 A. M.—Median dorsal apodeme of the base of the head.
 a. n. p.—Anterior notal wing process.
 ant.—Antenna.
 ant. fl.—Anterior flexor of the femur.
 ap.—Apodeme.
 b. s.—Basalar sclerite.
 C₁, C₂.—Cardo, first and second segments.
 Cerv.—Veracervix or neck region.
 c. hyp.—The compressor of the hypopharynx.
 c. m.—Constrictor (circular) muscles of the digestive tract.
 Cox.—Coxa.
 Cs.—Cercus.
 c. t.—Chitinous thickening of the tracheal wall.
 d₁, d₂.—Internal dorsal processes of the dorsal and ventral gonapophyses respectively.
 dep.—Depressor muscle.
 d. m.—Dilator muscle.
 d. sp.—Dilator of the spiracle.
 el.—Elevator muscle.
 Em.—Epimeron.
 Ep.—Episternum.
 ep.—Entopleurite.
 Eph.—Epipharynx.
 eph. m.—Epipharyngeal muscle.
 es.—Lateral entosternite (furca).
 es. m.—Median entosternite (spina).
 ext.—Extensor muscle.
 ext. a. s.—Extensor of the antennal segment.
 ext. p. s.—Extensor of the palpal segment.
 F. A.—Anterior foramen of head.
 fem.—Femur.
 F. L.—Lateral foramen of head.
 fl.—Flexor muscle.
 fl. a. s.—Flexor of the antennal segment.
 fl. g.—Flexor of the galea.
 fl. p.—Flexor of the palpus.
 fl. p. s.—Flexor of the palpal segment.
 F. O.—Occipital foramen.
 Fs.—Furcasternite.
 G.—Gena.
 Gal.—Galea.
 G. D.—Dorsal gonapophysis.
 Gl.—Glossa.
 G. V.—Ventral gonapophysis.
 hyp.—Hypopharynx.
 in₁, in₂.—Intersegmentalia.
 i. p.—Interpleurite of the veracervix.
 i. st.—Intersternites of the veracervix.
 i. tg.—Intergites of the veracervix.
 Lac.—Lacinia.
 Lb, lb.—Labium.
 Lbr., lbr.—Labrum.
 l. d.—Lateral dilator of the oesophagus.
 m. ant.—Antennal muscles.
 Md., md.—Mandible.
 Mx., mx.—Maxilla.
 Oc.—Ocellus.
 oc.—Occlusor muscle.
 Oes.—Oesophagus.
 P. A₈, P. A₉.—Anterior tergal processes (entotergites) of the eighth and ninth abdominal segments.
 Pcx.—Precoxae.
 P. G.—Postgena.
 Pgl.—Paraglossa.
 Ph.—Pharynx.
 p. l.—Posterior valve of spiracle.
 Pl. mb.—Pleural membrane.
 p. n. p.—Posterior notal wing process.
 P. P.—Podical plate.
 p. p.—Pleural wing process.
 pr. d.—Precerebral dilators of oesophagus and pharynx.
 P. S.—Sural plate.
 p. s.—Pleural sclerites of abdomen.
 Pscl.—Postscutellum.
 P. S. G.—Process of the supragenital plate.
 ps. p.—Parasternal plate.
 pst. d.—Postcerebral dilators of the oesophagus.
 r. hyp.—Retractor of the hypopharynx.
 r. lb.—Retractor of the labium.
 sa. p.—Subalar plate.
 Sc.—Scutum.
 Scl.—Scutellum.
 sp.—Spiracle.
 sp. c.—Spermatophore cup.
 Ss.—Spinasternite.
 st.—Stipes.
 Stn.—Sternum.
 t.—Tendon.
 T. A.—Anterior arm of the tentorium.
 tar.—Tarsus.
 T. C.—Central plate of tentorium.
 t. c.—Transverse chitinous beam connecting the ventral processes of the two dorsal gonapophyses.
 tend.—Tendon.
 Tg.—Tergite.
 tib.—Tibia.
 T. P.—Posterior arm of tentorium.
 tr.—Trochantin.
 Troc.—Trochanter.
 ung.—Claws.
 v₁, v₂.—Internal ventral processes of the dorsal and ventral gonapophyses, respectively.
 vag.—Vagina.
 vd.—Ventral dilators of the oesophagus.
 Vs.—Verasternite.

EXPLANATION OF FIGURES.

PLATE I.

- Fig. 1. Plan of part of the inner right side of the skeleton showing the endoskeletal structures and the attachment of the muscles. External sclerites are dotted, the internal sclerites and processes are shaded black, tendons are cross-hatched and the attachment of the muscles outlined with dotted lines.

PLATE II.

- Fig. 2. Ventro-caudal view of the epicranium showing the tentorial plates.
Fig. 3. Inner view of the right half of the extremity of the female abdomen.
Fig. 4. The mandibles and their muscles. On the left side several layers of the adductor are removed to show the tendons, on the right side the adductor is cut across to show its thickness.
Fig. 5. Front view of the head with the labrum, clypeus and front removed to show the heads of the adductors of the mandibles, the antennal muscles and the dilators of the oesophagus and pharynx.
Fig. 6. Longitudinal section through the head.
Fig. 7. The muscles of the labrum.
Fig. 8. Longitudinal section through the lateral side of the labrum, clypeus and part of the front.
Fig. 9. Same through the median line.
Fig. 10. Longitudinal section through the basal joints of the antenna.
Fig. 11. Portion of front of head showing the antennal muscles.

PLATE III.

- Fig. 12. Head with the greater part of the epicranium and internal tissues removed to expose the muscles of the maxillae.
Fig. 13. Ventro-caudal view of the head with the labium and gular region removed.
Fig. 14. Muscles of the maxilla.
Fig. 15. External muscles of the maxilla.
Fig. 16. Caudal view of the head with the integument of the mentum and sub-mentum removed exposing the labial and maxillary muscles.
Fig. 17. The muscles of the labium.
Fig. 18. The cervical muscles.
Fig. 19. External cervical muscles.

PLATE IV.

- Fig. 20. The inner layer of thoracic muscles, right side.
Fig. 21. (A) The outer layer of thoracic muscle. (B)* The outer layer of the mesothoracic muscles of the male.

PLATE V.

- Fig. 22. The articulation of the mesothoracic leg with the episternum and the sternum showing the fifth lateral muscle of the mesothorax.
Fig. 23. Inner side of the anterior face of the right metathoracic leg.
Fig. 24. Anterior face of the coxa of metathoracic leg with the extensors of the femur removed to show the flexors.
Fig. 25. Anterior face of left mesothoracic leg.
Fig. 26. Posterior face of the coxa and trochanter of the same.
Fig. 27. Ventral view of the claws and their flexing apparatus.
Fig. 28. Enlarged metathoracic longitudinal dorsal muscle of longwinged female.
Fig. 29. The nototrochanteric extensor of the femur.
Fig. 30. The notocoxal flexor.
Fig. 31. The notocoxal extensor.

PLATE VI.

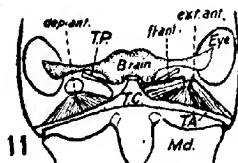
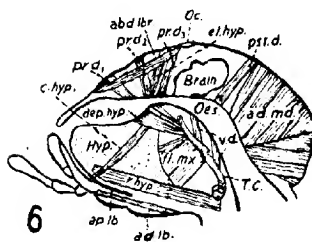
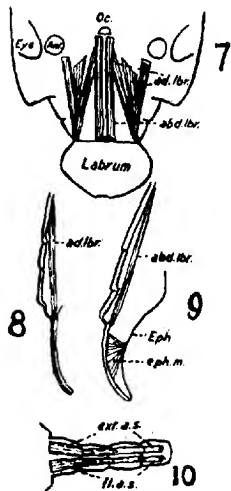
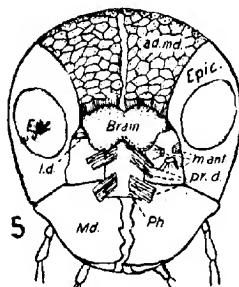
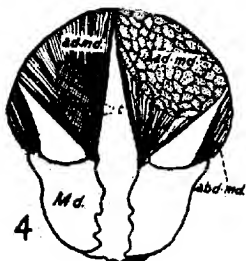
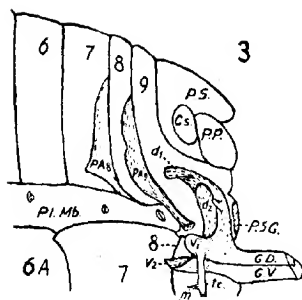
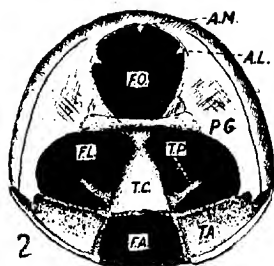
- Fig. 32. The muscles of the first five abdominal segments. In segments 3 and 4 the dorsoventrals are removed to expose laterals.
Fig. 33. Muscles of the extremity of the female, inner layer.
Fig. 34. Same, outer layer.

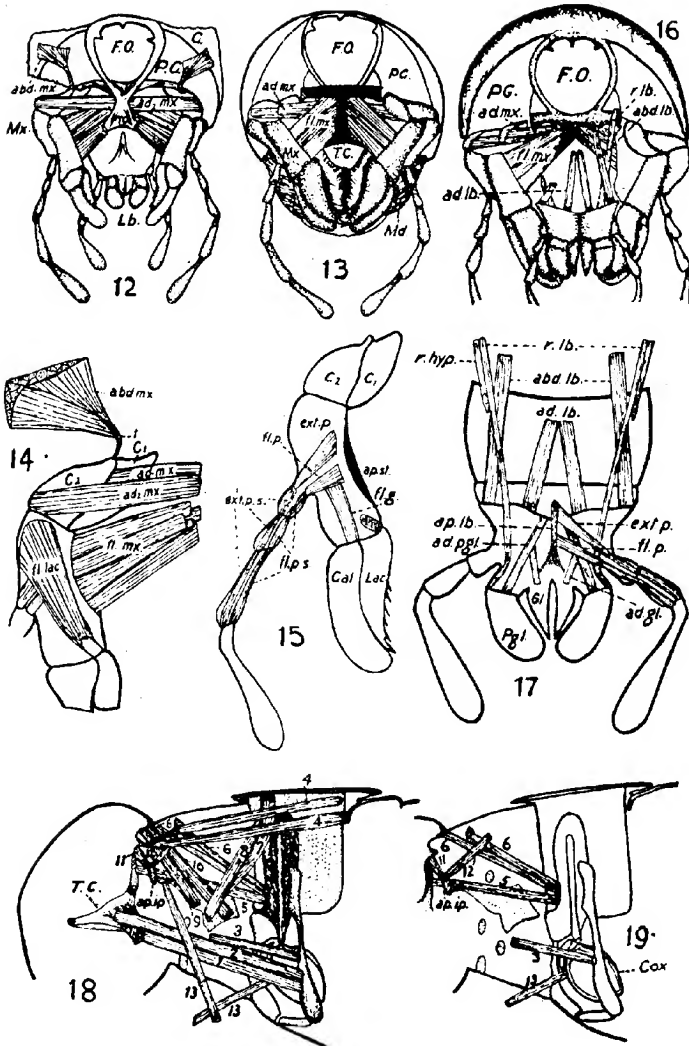
PLATE VII.

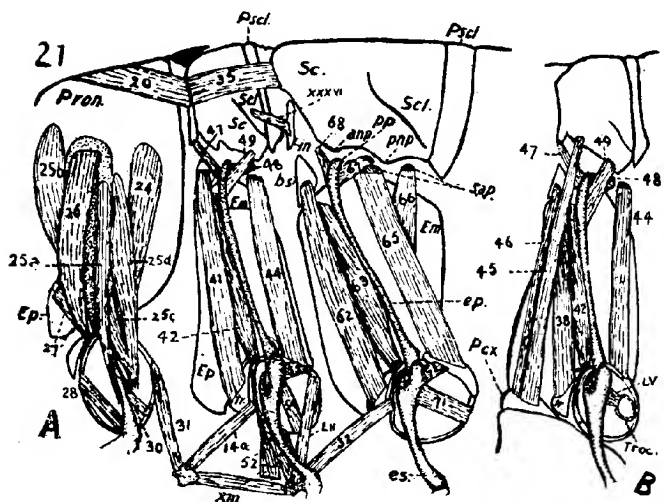
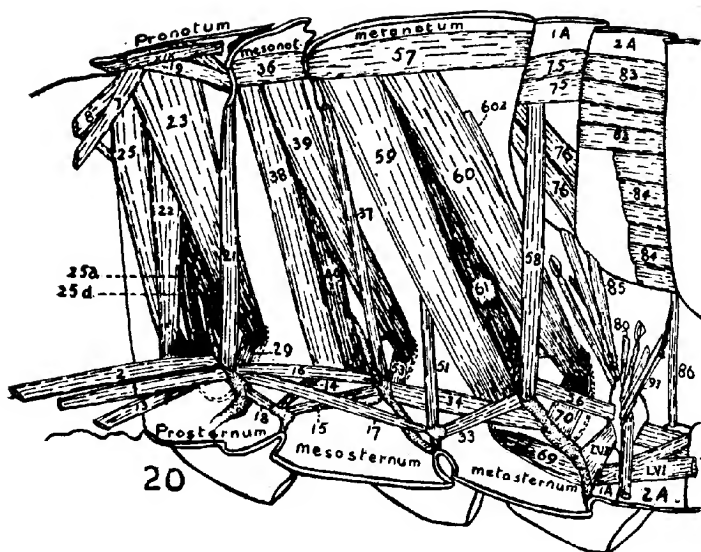
- Fig. 35. Muscles of the extremity of the male.
Fig. 36. Lateral view of the spermatophore cup and its muscles.
Fig. 37. Inner view of the mesothoracic spiracle.
Fig. 38. Inner view of the metathoracic spiracle.
Fig. 39. Same with the first occlusor removed.
Fig. 40. Inner view of an abdominal spiracle, open.
Fig. 41. Same, closed.
Fig. 42. Transverse section through one fold of the proventriculus.
Fig. 43. Transverse section of the rectum.
Fig. 44. External view of the rectum.



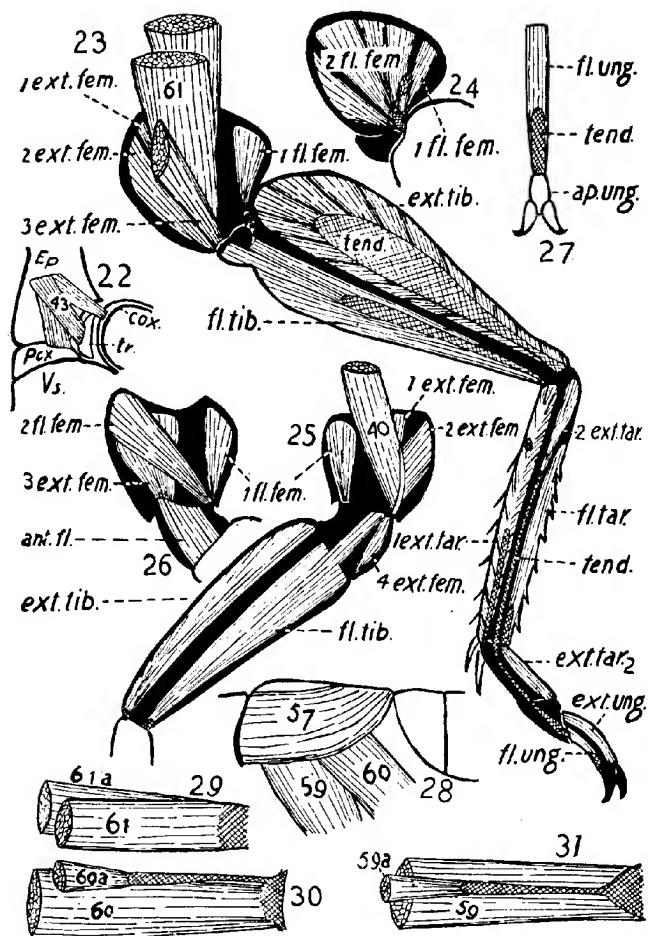
E. M. DuPorte.

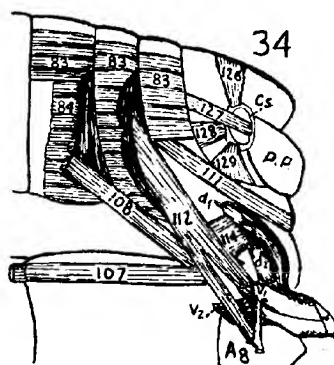
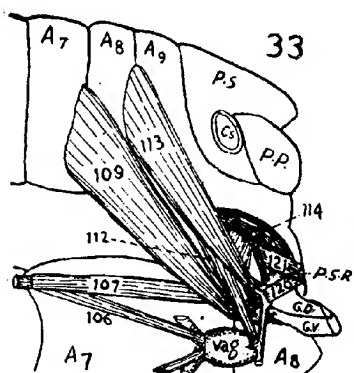
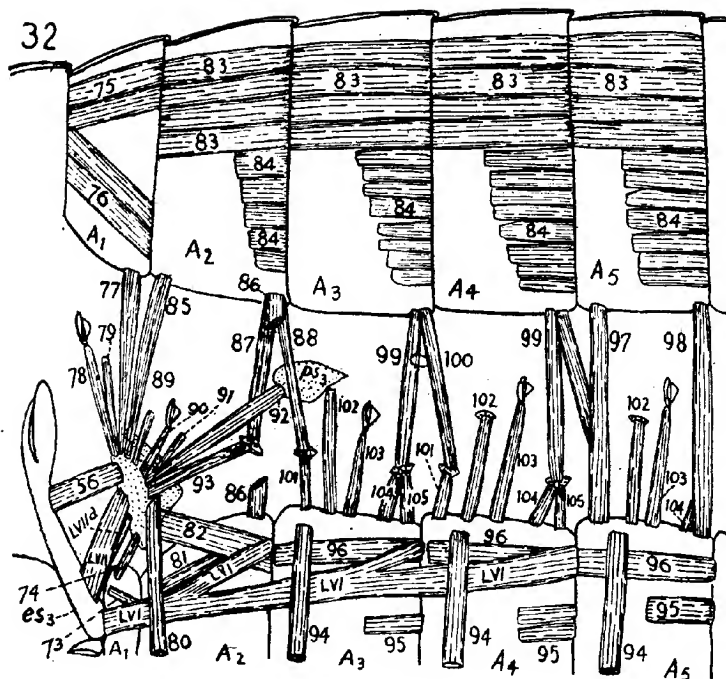


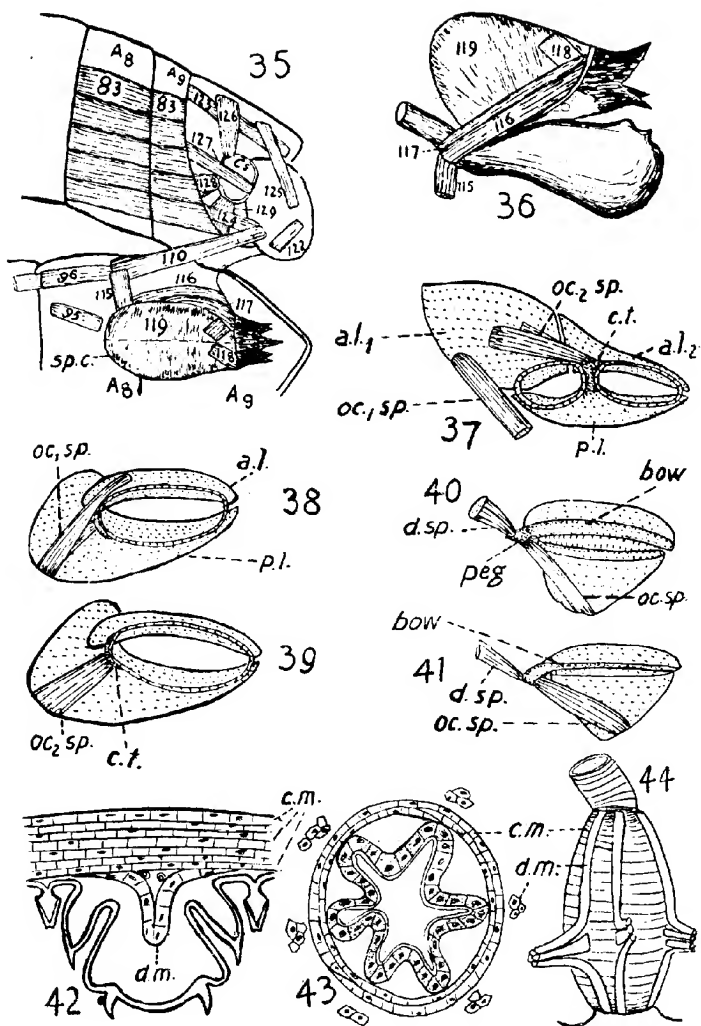




(NOTE—In Figure 21B for 38 read 41.)







ANT GUESTS FROM FIJI AND THE BRITISH SOLOMON ISLANDS.

By WILLIAM M. MANN,

U. S. Department of Agriculture, Bureau of Entomology.

The species hereafter described and noted were collected by the writer during 1915-1916, during an eighteen months' excursion to the South Seas as Sheldon Traveling Fellow of Harvard University.*

ORTHOPTERA. (Family Gryllidæ).

Myrmecophila hebardi sp. nov.

Female: Length 2.75-3 mm.

Form elongate and rather more slender than usual in the genus. Head brown, with a pair of yellow spots on the vertex. Thorax and first two abdominal segments lemon yellow; pronotum with a broadly interrupted fuscous band at middle; metanotum and first two abdominal segments with narrow, entire, transverse fuscous bands at base; remaining abdominal segments fuscous; the antennæ, tips of ovipositor and femora infuscated. Body and appendages with microscopic yellow pubescence; cerci with long and coarse hairs; thorax and abdomen above with scattered, squamiform hairs. Eyes flat, composed of 16-18 facets. Antennæ distinctly longer than the body and very slender. Pronotum slightly narrowed in front. Meso- and metanotum subequal in length and together slightly shorter than the pronotum. Cerci 9-jointed, rather stout, with joints 2-3-4 distinctly broader than long. Spines of posterior tibiæ arranged as follows: On the dorso-external margin at apical third, three spines, the basal of which is a little longer than the third, but only half as long as the second; the dorso-internal margin with six spines, the basal, the third and the sixth much shorter than the others; tips with a pair of short ventral spines. Metatarsus with one stout spine.

Host: *Plagiolepis longipes* Jerd.

Described from a series taken with the host ant in the following localities: Fiji Islands, Somo Somo, Taviuni (type locality), Lakeba, Munia and Kabara in the Lau Archipelago; Saïaro, Viti Levu; Vunisea, Kadavu. Santa Cruz Archipelago: Graciosa Bay. Solomon Islands: Pamua and Wainoni Bay, San Cristoval.

* The figures were drawn by R. S. McEwen.

The squamiform hairs on the thorax are difficult to see and in many of the specimens have been rubbed off.

M. hebaridi is close to *M. flavocincta* Wasmann, which lives with the same species of ant in India, but Rev. Wasmann has kindly compared the two and writes that in *hebaridi* the joints of the cerci are much broader than in *flavocincta* and the latter species has yellow bands only on the pro-and mesonotum.

M. hebaridi differs from the other species of *Myrmecophila* in confining itself to one host species. This probably accounts for the small amount of variation in size among the series before me. In a large collection of *Myrmecophila* the size of the crickets is seen to be in proportion to the size of the ant with which it lives. Small individuals are found in colonies of large ants, but in the collection before me, consisting of a series of nine species, it is very noticeable that the large-sized specimens of each species live with large host ants.

DIPTERA. (Family Syrphidæ).

Bardistopus papuanum gen. et sp. n.

(Fig. 1.)

(Near *Microdon*).

Female: Length 6.5 mm. Form very slender; color black with the sides of front, 2nd and 3rd antennal joints, apex of scutellum, metanotum, broad lateral stripes on first gastric segment and legs (except tarsi) reddish brown, tarsi yellowish white. Frons at vertex more than a third as broad as head, not narrowed toward antennæ, subquadrate in shape and barely longer than broad, coarsely and in parts confluent punctate. Ocelli flat, situated on a tubercle which is bordered in front and at sides by a deep groove. Occiput truncate. Face straight in profile, sides with coarse, short, black hairs and yellow pollinose pubescence. Antennæ very long; arista twice as long as basal joint; basal joint about six times as long as 2nd joint; terminal joint about seven times as long as the basal, very gradually thickened toward apex, which is rounded. Thorax coarsely and irregularly punctate and with abundant, semirecumbent, coarse, black hairs. Scutellum transverse, rounded above, unarmed, anterior posterior borders nearly straight. Metanotum strongly transverse; with a sub-circular, broad, shallow depression at middle, microscopically striolate and without hairs. Gaster four times as long as broad, rugulose and punctate, moderately densely covered with semirecumbent, silky hairs. First segment margined at sides and elevated in front; second segment transversely impressed in front, the impression deep near sides; third segment as long as the first and second together. Wings hyaline, veins brown. Halteres yellowish white.

Pawa; Ugi, British Solomon Islands.

Described from two females (one without developed wings) reared from pupæ found on a leaf in a nest of *Technomyrmex albipes* F. Smith.

The puparium is 7 mm. long and 4 mm. broad; is not as convex as those of *Microdon* and brownish in color and not reticulated.

I have considered *papuanum* as generically distinct from *Microdon* because of the structure of the antennæ.

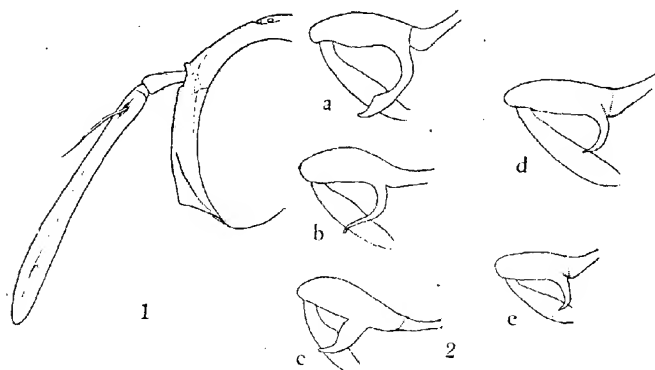


Fig. 1. *Bardistopus papuanum* gen. and sp. nov. Antenna and head from side.
Fig. 2. Middle femur, showing spines of a, *Fustiger vitiensis* sp. n.; b, *Fustiger raffrayi* sp. nov.; c, *Fustiger leverani* sp. nov.; d, *Fustiger wasmanni* sp. nov.; e, *Katsia oceanica* sp. nov.

COLEOPTERA. (Family Pselaphidæ).

(Subfamily Clavigerinæ).

No species of this group have hitherto been recorded from the Melanesian region, but as they occur in nearly all parts of the world, it was not surprising to find some in a region as old zoologically as Fiji.

Five of the seven species that I found were taken at Nadarivatu, in the high mountains of Viti Levu, and four of them in company with the same host species, *Pheidole knowlesi* var. *extensus* Mann (mss.)*, a common species in the islands and one that nests beneath stones, a situation most favorable for the

* The ants named as host have been described in a paper on the ants of Fiji, now in the hands of the editor.

discovery of any inquilines in the nest. One was found with a Fijian species of *Iridomyrmex*, nesting in a *Myrmecodia* bulb and two with *Prenolepis-bengalensis* Forel, an East Indian ant apparently well established in Fiji.

I am, with much doubt, placing five of my species in the genus *Fustiger*, though they are certainly exceedingly aberrant forms, and for two of the species I have considered it advisable to erect new genera.

***Fustiger vitiensis* sp. nov.**

(Fig. 2, a; Fig. 3.)

Male: Length 1.25-1.50 mm.

Head about twice as broad as long, broadest in front, shallowly impressed transversely between eyes, smooth in front and with shallow, foveolate punctures behind. Antennae longer than head, the third joint narrow basally, gradually enlarged for two-thirds its length and then suddenly thickened so that the apical third is sub-campanulate; basal two-thirds densely punctate and much darker in color than apical third, which is smooth and shining. Prothorax longer than broad and a little more than half as broad in front as behind; sides convex. Sides of elytra feebly arcuate, posterior angles obliquely truncate, middle of border moderately concave. Abdomen with basal pit deep but not broad, lateral glandular swellings evenly rounded, only moderately excavated beneath; margins strong. Femora narrow basally, moderately swollen at apical two-thirds; the middle pair with thick spines which are broadened and subangulate in front of middle; the spines two-thirds as long as tibiae.

Brownish red. Hairs yellow, coarse and straight, moderately abundant on head, thorax, abdomen and antennae; short and sparse on legs. Fascicle well developed.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from a series taken at Nadarivatu, Viti, Levu, Fiji.

***Fustiger raffrayi* sp. nov.**

(Fig. 2, b.)

Near *Fustiger vitiensis* from which it differs in the following characters:

The prothorax is proportionately longer and more than twice as broad behind as in front. The femoral spines are slender and bisinuate and not enlarged and angulate on inner border. The head is not strongly punctate on the posterior half. The size (length 1 mm.) is slightly smaller.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from several specimens taken at Vunisea, Kadavu, Fiji.

Fustiger cribratus sp. nov.

(Fig. 4.)

Male: Length 1.10 mm.

Dark brown, almost black. Head prothorax and elytra finely cribrately punctate and with microscopic recumbent hairs; abdomen, in addition to similar minute hairs with six long, fine and erect hairs.

Head less than twice as long as broad, as broad behind eyes as in front. Antennae twice as long as head, slender, clavate and compressed apically. Prothorax a little longer than broad, sides rather strongly

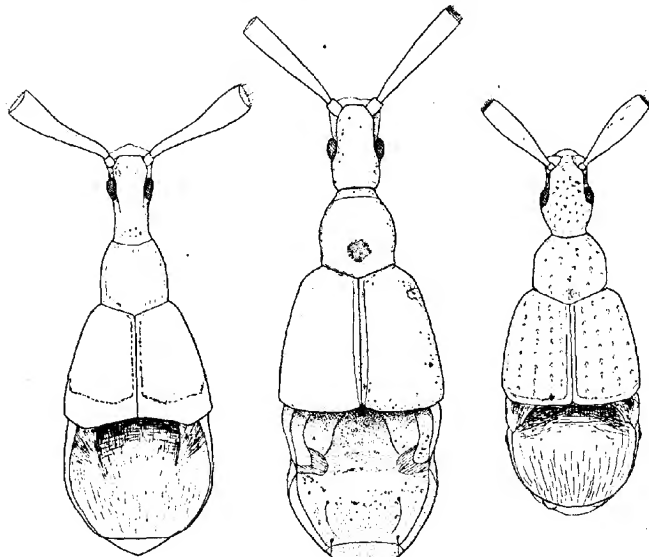


Fig. 3.

Fustiger vitiensis.

Fig. 4.

Fustiger cribratus.

Fig. 5.

Fustiger levuanus.

convex at middle, straight behind, dorsal surface with a strong circular impression at middle near base. Elytra together distinctly longer than broad, sides convex, apical corners rounded, sutural striae strong. Abdomen narrow; pit short and deep with strongly sloping posterior surface, lateral anterior lobes elongate, well defined, excavated beneath, with fascicle at the tip composed of short hairs; posterior portion of abdomen convex, strongly margined at sides. Anterior femora strongly swollen at middle of inner edge. Spines of middle femora thick basally, then slender and acuminate apically, strongly curved.

Viti Levu: Nadarivatu.

Host: *Iridomyrmex sororis* Mann.

Described from two males taken with the host ant, in a *Myrmecocodia* bulb.

The elongate, slender antennæ, the regular punctation and the dark color are characteristic of *cribratus*.

Fustiger levuanus sp. nov.

(Fig. 2, c; Fig. 5.)

Male: Length 1.25 mm.

Reddish brown. Head, prothorax and elytra with rather stiff, sub-erect hairs; abdominal fasciculæ very small. Head less than twice as long as broad, widest behind eyes, coarsely, foveolately punctate. Antennæ about as long as head, second joint clavate, compressed at tips, uniformly punctate. Prothorax broader than long, broadest behind eyes, sides convex, surface foveolately punctate. Elytra a little broadest behind, sides convex, posterior corners rounded, surface with rather strong and regular foveolate punctures which become finer on apical third. Basal pit of abdomen not deep; barely one-third as long as abdomen; the surface posterior to the pit very strongly convex. Femora incrassate, the spines about half as long as tibiae, stout basally and strongly curved. Disc of metasternum impressed, first gastric segment barely as long as second and third together.

Koro Vatu, Viti Levu, Fiji.

Host: *Prenolepis bengalensis*. Forcl.

Nadarimanu gen. nov.

NOTE.—Near *Fustiger*, but differing in the structure of the abdomen, which is very strongly margined for its entire length and instead of a fasciculate inflation at the anterior end has a second, rounded margin which bears an elongate brush of hairs. Abdominal pit very broad, the posterior face flat and sloping and the non-excavated posterior part of the first segment reduced to a convex ridge. Type *alewa*.

Nadarimanu alewa sp. nov.

(Fig. 6*)

Female: Length 1.75 mm.

Reddish brown. Hairs rather coarse, curved, semirecumbent, abundant on head, body and appendages. Head, prothorax and elytra with strong, foveolate punctures which are largest and more shallow on the elytra. Abdomen very finely and sparsely punctate. Head about twice as long as broad, as broad at anterior border as behind eyes, not impressed above. Antennæ much longer than head, the third joint rather narrowly clavate and compressed. Prothorax a little longer than broad, narrowed in front, sides convex at anterior half, nearly straight behind; surface feebly depressed at base. Elytra together broader than

* The antennæ are more sinuate than shown in the figure.

long, sides feebly convex, posterior angles sharp, border bisinuate; sutural striae strong. First abdominal segment strongly margined for its entire length, without dilations, but with a second rounded margin which extends along the sides of the pit, this bearing along the sides a long, thin fascicle; pit very broad and shallow, extending four-fifths the length of the segment; its posterior three-fourths, very flat and sloping. First ventral segment longer than the following three together. Ventral surface of head and thorax with very coarse punctures, legs stout, femora enlarged and moderately compressed.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from one female taken on Mt. Victoria, Viti Levu, Fiji.

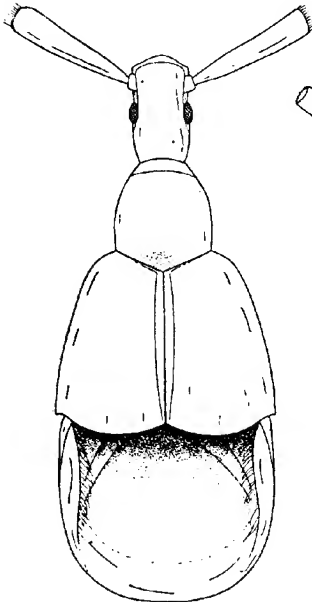


Fig. 6.
Nadarimannu alerwa.

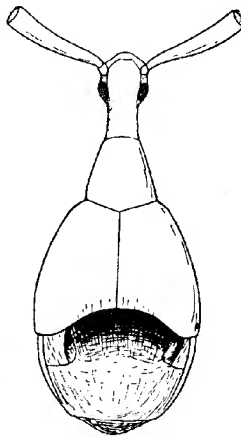


Fig. 7.
Fustiger wasmanni.

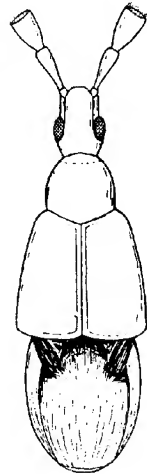


Fig. 8.
Kaisia oceanica.

***Fustiger wasmanni* sp. nov.**

(Fig. 2, d; Fig. 7.)

Male: Length 1.25 mm.

Head constricted behind eyes into a neck, which is broadest basally, about two-thirds as broad and a little shorter than the anterior portion; the ventral surface strongly longitudinally impressed at middle with the

sides roundly margined. Antennæ distinctly longer than head. First joint smaller than the second, second joint transverse broader than basal portion of third. Third joint thick, markedly enlarged at apical third, circular and truncate at apex. Prothorax broad basally, narrowed in front, with nearly straight sides. Elytra together much broader than long, sides feebly arcuate, posterior corners narrowly rounded, the posterior margin truncate at sides and deeply concave at middle. Abdomen broad, the basal fovea extremely deep, grooved at bottom; dorsal surface posterior to pit strongly concave; lateral swellings large, deeply excavated and bearing extremely thin fasciculæ; side margins acute at anterior third, less so behind. Ventral surface of metathorax broadly rounded. First abdominal segment much longer than the following three segments together. Legs slender, the middle femora with short spines which are thick basally, narrowed apically, strongly curved and about one-third as long as tibiae.

Yellow brown, shining, thorax and abdomen sparsely, regularly punctate. Head in front of eyes sparsely, rather coarsely punctate, posteriorly with strong, elongated and confluent foveolate punctures. Hairs yellow, coarse, strongly curved and moderately abundant on antennæ.

Host: *Pheidole knowlesi* var. *extensus* Mann.

Described from a unique male taken at Nadarivatu, Viti Levu. Fiji.

The broad, oval form, the shape of the head, the thickly margined inferior sides of the neck and the exceedingly profound abdominal pit are very distinctive.

Kaisia gen. nov.

NOTE.—Kaisi (Fijian) = slave.

Form elongate. Head longer than broad. Eyes well developed. Antennæ four-jointed, the first joint very small, the third longer than the fourth which is truncate apically. Prothorax broad, strongly impressed at base. Elytra elongate. Abdomen small, with a deep, narrow pit in front and well developed lateral swellings and fasciculæ. Metasternum with a pair of broad foveæ which are separated by a longitudinal ridge of pubescence; apical margin with a pair of strong vertical spines. Type *oceanica*.

Kaisia oceanica sp. nov.

(Fig. 2, c; Fig. 8.)

Male: Length 1 mm.

Reddish brown. Hairs rather strong and sub-erect, regularly arranged and moderately abundant on head, pronotum elytra and abdomen. Fasciculæ of abdomen well developed, dense. Head less than twice as long as broad, as broad in front as behind, widest behind eyes, not impressed above; rugosely punctate. Eyes large and convex, sit-

uated at sides of head a little behind the middle. Antennae a little longer than head, with three distinct joints; first joint small; second joint clavate, one and one-third times as long as the terminal from which it is separated by a strong constriction, punctate; third joint smooth and shining, nearly twice as broad as the second, broadest at apex, tip truncate. Prothorax slightly broader than long with a strong, elongate impression at middle of basal half, punctate similarly to head. Elytra together longer than broad, posterior corners broadly rounded, border shallowly concave at middle; coarsely shallowly and rather

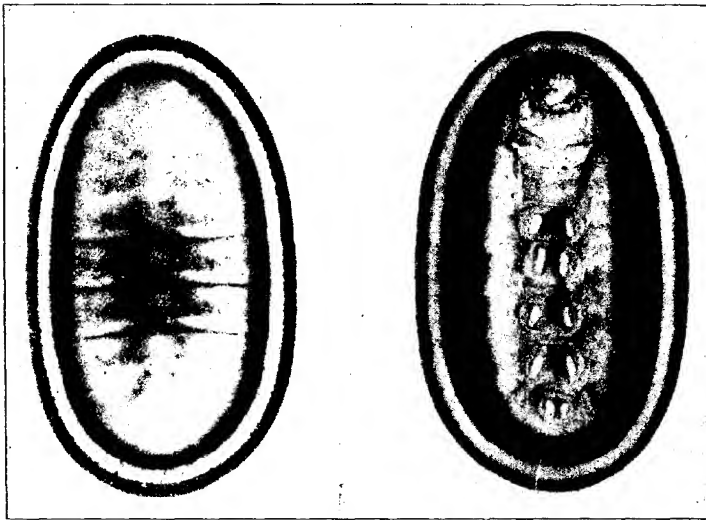


Fig. 9. *Liphya brassolis* Westw. larva, dorsal and ventral views.

sparsely punctate. Abdomen distinctly narrower than elytra; first segment with strong lateral margin; anterior glandular processes moderately developed; pit small, occupying less than one-third of the surface, transverse, grooved at bottom. Femora of uniform thickness, armed basally with a rather thick spine, a little less than half as long as the femur, nearly straight at basal two-thirds, then bent at a rounded obtuse angle. Mesosternum apically with a pair of strong elongate, triangular spines in front of inner margin of posterior coxi. First ventral segment as long as the second and third together.

Host: *Prenolepis bengalensis* Forel.

Described from two specimens taken with a colony of the host ant beneath a stone on the Tai Levu Coast, Viti Levu, Fiji.

LEPIDOPTERA. (Family Lycacnidæ).

***Liphyra brassolis* Westw.**

(Fig. 9.)

Several individuals of the singular, Dipterous-like larvæ of this species were found at Tulagi, British Solomon Islands, in the leaf and silk nests of *Oecophylla smaragdina* var. *subnitida* Emery. *L. brassolis* is found from Australia to India. It feeds on the larvæ of the host ant. The latter are unable to harm it, because of the heavy corneous larval skin, the edges of which fit closely to the leaf. At the time of pupation the larval skin becomes modified into a cocoon, within which the quiescent stage is passed; a condition analogous to that of the cyclorrhaph Diptera. When the adult emerges it is densely covered with scales which come off if the ants become aggressive and distracts their attention while the *Liphyra* escapes from the nest.

The larvæ much resemble those of *Microdon*, and glide along in a similar manner, though very much faster.

* Dodd (Ent. 35, pp. 153-156, 1906) has given an interesting account of the habits, and Chapman (Ent. 35, pp. 225-228 and 252-255) of the development of specimens from Queensland.

THE PROCESS OF HATCHING IN CORYDALIS CORNUTA LINN.

ROGER C. SMITH, Ph. D.,

U. S. Entomological Laboratory, Charlottesville, Va.

A study of the manner of hatching of *Corydalis cornuta* was made to ascertain if there were an egg burster used. Dr. C. V. Riley (1876) stated in his observations on the life history of *Corydalis cornuta* Linn that "the egg burster* has the form of the common immature mushroom and is easily perceived on the end of the vacated shell." This note was repeated in his ninth annual Missouri Report, 1877 (p. 127). This is the only published account of hatching known to the writer, but in part has been quoted by many writers since its appearance. Through the kindness of Professor A. N. Caudell, of the National Museum, an abundance of preserved material was made available for study. Throughout the month of July of the current year, a large number of egg masses of *Corydalis cornuta* were found along a small stream near this laboratory on rocks in the stream and on several overhanging trees. Some were taken to the laboratory and observed for hatching.

There appears to be no doubt that Professor Riley misinterpreted a rather unusual shaped micropyle (Fig. 1) for an egg burster as suggested by Davis (1903). This micropyle, as is generally the case, is located at one end of the elliptical egg and in the Sialidæ, to which *Corydalis* belongs, has somewhat the shape of certain mushrooms in the button stage. It is attached to the exterior of the chorion and not to an inner structure as might be expected if it were an egg burster. It was not observed to serve any purpose whatsoever in hatching.

Professor Riley states further that egg bursters are generally if not always a part of the ambion (amnion, perhaps). This until relatively recently, perhaps to Heymon's work, 1906, appears to have been the prevailing opinion concerning egg bursters and we find in literature statements many times regarding the molting of the amnion at hatching.

* I am not aware that this special structure has been named. It is generally if not always, a part of the ambion, and common to many insects, though varying much in form. It may be known as the ruptor ovi. Dr. Hagen has called it the "egg burster," while erpetologists designate as "egg tooth," a structure having the same purpose.

Heymons (1906) states that the egg burster of the Pentatomidæ is a thickening and specialization of the embryonic cuticula. This cuticula is a very thin delicate structure undoubtedly rudimentary. It is molted at hatching and with it goes the egg burster. The writer has investigated the egg burster in the Chrysopidæ. It likewise is a specialized chitinous apparatus situated on the thin embryonic cuticula and the whole is shed at hatching. The molt was observed to withstand the action of heated caustic potash without injury and is undoubtedly chitinous. The writer concluded from a rather



Fig. 1.



Fig. 2.

Fig. 1. A micropyle of an egg of *Corydalid cornula* highly magnified.

Fig. 2. Ventral aspect of an egg of *Corydalid cornula* ready to hatch. Note the large mandibles, the two ocellar fields and the absence of an egg burster in the mid ventral cephalic region.

brief study of the embryology of the Chrysopidæ that the amnion was ruptured during the development of the embryo and was drawn into the mid-intestine with the last of the yolk to disintegrate or be absorbed. So the statement that they are generally if not always on the amnion can not be accepted in the light of later research. All egg bursters so far recorded are on a chitinous embryonic cuticula, which in most cases is shed at hatching as for example in the Chrysopidæ, Hemerobiidæ, Pentatomidæ, Trichoptera and the Psocidæ. Lepisma and the Pulicidæ are said to retain the egg bursters for a day or longer,

but no recent accounts have been given of this fact in either case. In *Corydalis cornuta* there is an embryonic molt, but a careful study of the same has not revealed any structure that might serve as an egg burster. Furthermore, the process of hatching gives no indication of the use of any such structure. On the other hand, hatching is effected by a means none the less interesting and perhaps unusual.

When egg masses of *Corydalis cornuta* are cut or scraped from their substratum, some eggs which are ready to hatch will often hatch in a short time, so that hatching may be readily observed. Frequently eggs that are ready to hatch, judging from external appearances, may hold over for several days. The hatching process proceeds rather slowly and varies in the length of time between stages. Eggs ready to hatch are smoky gray, often reddish or pinkish in the lower three-fourths and lighter gray anteriorly. On the venter of the egg, the amber colored bifid mandibles can be seen about one-third the distance from the anterior end of the egg (Fig. 2). At the sides can be plainly seen the two large black eye spots or ocellar fields, each with seven ocelli. The head of the embryo is therefore bent caudo-ventrad with the prothorax beneath the micropylar area.

Usually the first visible evidence of hatching is slight movements of the embryo. Under highest power binocular, air bubbles will be seen to be slowly going down the pharynx. As this continues the anterior region of the egg becomes perceptibly dilated. The chorion shrinks slightly as the air within is withdrawn until it becomes rather closely appressed to the embryo, suggesting premolting conditions. The contour of the embryo can now be plainly seen, the large head being very evident. The egg becomes asymmetrical, due to the enlargement anteriorly and the shrinkage around the abdomen posteriorly. As the swallowing of air bubbles continues, the embryo exerts considerable additional pressure by pushing itself upward. The chorion over the anterior end of the egg becomes tightly stretched under the increasing internal pressure and finally gives way, providing the opening for the emergence of the larva. The rent is usually small at first and difficult to see, but soon increases to accommodate the large head of the embryo. In no case did the mandibles pierce the chorion to

start the rent. The embryo pushes itself feebly upward, the dorsum of the head first appearing. This upward shifting continues until the sixth or seventh abdominal segment is reached. During the emergence the swallowing of air bubbles increases in rate. The embryo normally stops at this stage of emergence for a varying period of time. It now casts off the embryonic molt in precisely the same way as hatching is effected. By continued swallowing of air the old cuticula is stretched further. Finally the swallowing of air bubbles is discontinued and the larva begins to work the abdomen forward as is done in many insects at molting. As the abdomen is brought forward within the old cuticula the thoracic region becomes greatly strained and finally tears over the prothorax. Immediately the broad, somewhat angular prothorax appears. The setae straighten up as the smooth glassy coat slips back. The thorax is slowly pushed through the rent. The molt is held back by the mouth parts causing the head to be turned ventrad so that the larva forms a loop over the egg.

The heavy chitinous mandibles and abdominal hooks are not shed as might be expected. This thin embryonic cuticula resembles more a tight fitting sack than a true molt. It is probably not attached (or is very loosely attached) to the inside of the chorion at some place as in the Chrysopidæ and Pentatomidæ for many embryos in confinement tumble from the egg and fail to cast this embryonic molt. All such larvæ died. The legs before shedding this molt are useless and the lateral abdominal filaments are bound close to the body. After the molt the larvæ are very active and the filaments expand to their normal position. This molt lies normally in the rent of the egg shell.

The writer concludes that hatching and the first molt are effected by the swallowing of air bubbles combined with the upward pushing of the embryo. The rent in the chorion is at the anterior end generally at one side of the micropyle. If the empty chorion be mounted and examined microscopically it will be seen that the rent is generally ragged and has the appearance of being torn by internal pressure. Sometimes the entire upper end of the egg is torn off as if it were a cap.

The phenomenon of swallowing air bubbles to effect hatching and molting has been recorded several times in literature.

Kunckel (1890) pointed out that nymphs of the Acridelideidæ accumulated air in their crops, causing the "ampoule cervicale" of each to become dilated which in turn raised the lids of their earthen cases. He states further that the swallowing of air bubbles is the chief means of molting. Peyerimhoff (1901) states that the embryos of the Psocids regularly swallow air bubbles to increase their size and enable them to exert the necessary pressure at hatching. This writer also gives a brief summary to date of the literature on the point. Heymons (1906) has noted the increase in size of Pentatomid nymphs at hatching by taking in air and adds that Foriculidæ do likewise at molting and hatching. The phenomenon is perhaps more common than a bibliography indicates.

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SOME OBSERVATIONS ON THE GENITALIA OF LACHNOSTERNA.

By W. P. HAYES and J. W. MCCOLLOCH,
Kansas State Agricultural Experiment Station.*

In making a study of the *Lachnosterna* of Kansas, the writers have examined approximately 50,000 specimens for specific determination. The works of Horn (1887) and Smith (1889) were used in most of this work. Smith's paper was especially helpful in making specific determinations, because of the large series of figures illustrating the genital characters which are now generally recognized as the best means of separating the different species of this genus. Several species of *Lachnosterna* occur in Kansas, however, that are not figured in this paper, and in order to facilitate the identification of them, illustrations of the genitalia were prepared.†

Since many others are working with this group, it seemed advisable to present these figures at this time in the nature of a supplement to Smith's paper. It is not the purpose of the writers to go into detail concerning the identification of the various species, since Glasgow (1916) states that he is making a thorough systematic study of the genus. Several discrepancies in Smith's figures of *L. corrosa*, *L. crenulata*, and *L. rubiginosa* are also discussed. In addition, a brief discussion is made of specific and sexual determination in the pupal stage.

DISCUSSION OF GENITALIA.

*Lachnosterna prætermis*a Horn (Plate I, Fig. 7).

This species is occasionally taken in Kansas, seven females and four males having been collected in the vicinity of Manhattan. The figures of the male genitalia are presented by Smith. The female genitalia approach that of *L. implicata*. Superior plates are wanting and the pubic process is characterized by being heart-shaped, deeply cleft, slightly divaricate and clothed with a sparse covering of short, erect hairs.

*Contribution from the Entomological Laboratory, Kansas State Agricultural College, No. 49. This paper embodies the results of some of the investigations undertaken by the authors in the prosecution of project No. 100 of the Kansas Agricultural Experiment Station.

†The writers wish to express their thanks to Mr. J. J. Davis for the determination of the specimens from which the Figures are prepared.

Lachnosterna longitarsa Say (Plate I, Fig. 4).

A good series of this species was taken in flight at Manhattan during the summer of 1917. Illustrations of the female genitalia are lacking in Smith's paper. In the female the inferior plates are subquadrate and the superior plates are triangular. The pubic process is reduced to a small protuberance between the superior plates.

Lachnosterna hirtiventris Horn (Plate I, Fig. 3).

A number of specimens of this species are in the writer's collection from southern Kansas. Only the male genitalia are figured in Smith's work. The superior plates in the female are lightly corrugated and the pubic process is deeply cleft and slightly divaricate.

Lachnosterna calceata Lec. (Plate I, Fig. 1).

L. calceata is a common species in the southern half of Kansas. Smith does not figure either sex of this species. The genitalia of the male are symmetrical and approach the *L. crassissima* type. In the female the superior plates are modified into the pubic process which is elongate, bifid and tapering to a point.

Lachnosterna glabricula Lec. (Plate I, Fig. 6).

The males of this species are common in the vicinity of Manhattan during July and August. Three females were found around the roots of sumach (*Rhus* sp.) in 1917, in an area from which the males were emerging in large numbers. The pubic process in the female is wanting. The superior plates are fused, deeply emarginate and fringed on the posterior end with moderately long hairs.

Lachnosterna tristis Fab. (Plate I, Fig. 5).

This species is rare in some sections of Kansas. Smith presents figures of the male genitalia only. The female genitalia are rather simple as in *L. heterodoxa*, consisting of an unique development of the inferior plates. In the case of *L. tristis*, the grooves formed by a fold on the ventral side of the inferior plates are longer and apparently deeper than in *L. heterodoxa*. The posterior ends of these plates are fringed with slightly recumbent hairs.

Lachnosterna corrosa Lec. (Plate I, Fig. 2).

This species is frequently encountered in Kansas. According to Glasgow (1916) *L. affinis* is synonymous with *L. corrosa*. An examination of the specimens at hand show a variation in the genitalia of both sexes from the illustrations presented by Smith for either *L. corrosa* or *L. affinis*. In general they more nearly approach the *L. affinis* type. In the males the claspers are seen to be unsymmetrical. The female genitalia are rather characteristic. The inferior plates are large and are notched to receive the greatly reduced and modified superior plates. The pubic process is prolonged, divaricated and sparsely clothed with hairs.

Lachnosterna crenulata Froel., and **Lachnosterna rubiginosa** Lec. (Plate I, Figs. 8 and 9).

These two species occur in Kansas, the latter being one of the most common species in the vicinity of Manhattan. Both species are readily separated by the character of the lateral margin of the thorax which is strongly crenate in *L. crenulata* and but feebly so in *L. rubiginosa*. The genital organs of the females of both species are rather simple and very similar. The superior plates are fused along the median line and are deeply emarginate. A small, tooth-like projection occurs at the base of this emargination in *L. rubiginosa*. In Smith's figures, this tooth-like process is shown in *L. crenulata*. The superior plates are fringed with hairs of moderate length, the hairs being more numerous in *L. crenulata*.

SPECIFIC DETERMINATION IN THE PUPA.

Since it is often desirable to be able to identify the species of *Lachnosterna* pupæ, the following observations are offered as an aid of considerable value in the case of pupæ that have reached a somewhat advanced stage of development. As is well known, the grubs are not specifically separable and it is usually necessary to rear them to adults in order to make determinations. Often they reach the pupal stage and die. Fortunately, the genitalia develop at a comparatively early stage and so lie within the body of the pupa that they become visible through the pupal skin after the adult coloration begins to develop.

The sexes are easily distinguished as soon as pupation occurs. The lamellate club of the antennæ in most species is larger in the male than the female, and thus affords one means of determination. However, this offers some difficulty in species where size differences are not pronounced. In such instances, a second and more reliable method can be adopted. On the ventral surface of the female pupa, immediately cephalad to the anal slit, are two elevated subquadrate structures (Plate II, Fig. 10 r) which are characteristic of female pupæ. In the male (Plate II, Fig. 11 r) the same structures are present, but lying somewhat between and caudad to them is a third rounded and somewhat conical elevation (Plate II, Fig. 11 t) which is characteristic of all male pupæ examined. The sex of *L. lanceolata* is also determinable by the size and shape of the male and female pupæ.

The anal aperture of the adult beetle developing within the pupa is so opened as to allow the genitalia of both the males and females to protrude enough to be discernable under the pupal skin. They can be seen under and in the near vicinity of the structures described above, which are used in sex determination. All that is needed is a familiarity with the genitalia of the different species. Figure 11-N shows a ventral view of the posterior region of a male pupa of *L. crassissima*, and Figure 11-O is a lateral view of the same. In both views the male genital organ can be plainly seen in the region marked "x." Figure 10-L is a ventral view of the female of the same species, and Figure 10-M is a lateral view. In the female the genital organ may be found somewhat anterior to the two lobular subquadrate structures, as shown in Plate II, Fig. 10-p, or they may lie directly beneath them.

As stated, the genitalia are only visible after the body begins to assume its darkened coloration. Records kept during the past summer show this time of coloring to vary, but it is of sufficient duration in a large number of cases to enable determination to be made over the latter half of the pupal period. The pupal period of *L. crassissima* was found to vary from 16 to 58 days, with an average, for 178 individuals observed, of 30.5 days. The following table shows, in a few individuals observed, the time elapsing between pupation and the date when specific determination was possible, as well as the time during which the genitalia were visible.

TABLE I.
PERIOD OF PUPAL DETERMINATION.

Species	Number of days from pupation to determination	Number of days from determina- tion to maturity	Length of pupal stage days	Sex
<i>L. crassissima</i>	14	15	29	♀
	13	16	29	♀
	7	22	29	♂
	15	13	28	♀
	16	12	28	♂
	15	15	30	♂
	14	16	30	♀
	15	15	30	♂
	12	18	30	♂
	12	18	30	♂
	17	11	28	♂
	5	25	30	♂
	15	14	29	♂
	13	18	31	♂
<i>L. rubiginosa</i>	10	18	28	♂
	26	4	30	♀
	24	4	28	♀
	22	6	28	♀
	11	19	30	♂
<i>L. rugosa</i>	17	13	30	♂

Two striking cases are to be noted in the case of *L. crassissima* when the pupal specific identification was made 22 and 25 days before maturity in pupæ, whose complete pupal stages were 29 and 30 days, respectively. The genital plates of the females of *L. rubiginosa* are not very prominent even in the adults which may account for the shorter period allowed for the determination in the three females noted in the table. Other species in which similar determinations were made include *L. implicata*, *L. crenulata*, *L. prætermessa*, *L. bipartita*, *L. corrosa*, and *L. lanceolata*.

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EXPLANATION OF PLATES.

PLATE VIII.

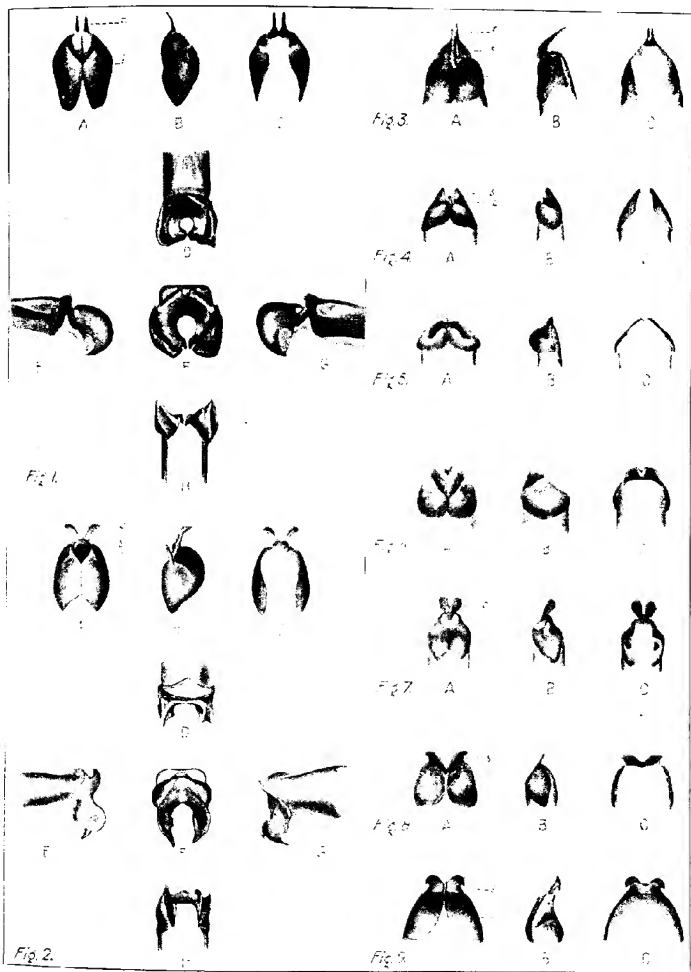
- Fig. 1. Genitalia of *L. calceata*, male and female.
 Fig. 2. Genitalia of *L. corrossa*, male and female.
 Fig. 3. Genitalia of *L. hirtiventris*, female.
 Fig. 4. Genitalia of *L. longitarsa*, female.
 Fig. 5. Genitalia of *L. trisitis*, female.
 Fig. 6. Genitalia of *L. glabricula*, female.
 Fig. 7. Genitalia of *L. prætermissa*, female.
 Fig. 8. Genitalia of *L. crenulata*, female.
 Fig. 9. Genitalia of *L. rubiginosa*, female.

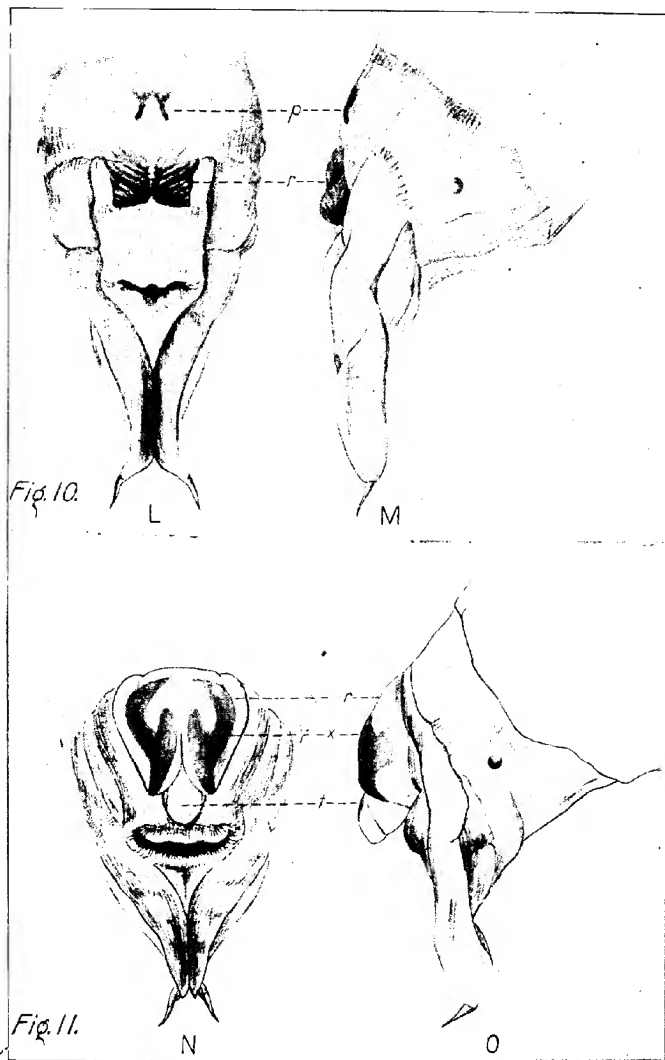
PLATE IX.

- Fig. 10. Caudal segments of pupa of *L. crassissima*, female.
 Fig. 11. Caudal segments of pupa of *L. crassissima*, male.

ABBREVIATIONS USED IN FIGURES.

- | | |
|---|---------------------------|
| A. Female genitalia, ventral view. | |
| B. Female genitalia, lateral view. | |
| C. Female genitalia, dorsal view. | |
| D. Male genitalia, dorsal view. | |
| E. Male genitalia, left clasper, lateral view. | |
| F. Male genitalia, caudal view. | |
| G. Male genitalia, right clasper, lateral view. | |
| H. Male genitalia, ventral view. | |
| L. Caudal segments of pupa of ♀ <i>L. crassissima</i> , ventral view. | |
| M. Caudal segments of pupa of ♀ <i>L. crassissima</i> , lateral view. | |
| N. Caudal segments of pupa of ♂ <i>L. crassissima</i> , ventral view. | |
| O. Caudal segments of pupa of ♂ <i>L. crassissima</i> , lateral view. | |
| i. Inferior plates. | s. Superior plates. |
| p. Pubic process. | t. Conical protuberances. |
| r. Subquadrate structures. | x. Male genitalia. |





**A REVIEW OF THE SPECIES OF THE GENUS GYPONA
OCCURRING IN NORTH AMERICA NORTH
OF MEXICO (HOMOPTERA).**

By E. D. BALL.

Germar founded the genus *Gypona* in 1821 for *Cercopis glauca* Fab. and its allies. Since that time 198 species have been described or referred to this group all from North and South America. Of this number over 100 have been named from North America.

The genus as a whole is composed of large broad and striking species of wide distribution but of comparative rarity in collections partly on account of their agility in avoiding capture and partly on account of restricted food habits. Most of the species are widely variable in size and structure and still more unstable in color. In several groups the males are usually strikingly and variably ornamented while the females are plain.

The majority of these so-called species have been described from single examples or single sexes and little attention has been given to previous work. Spangberg in 1878 in his *Species Gyponæ* lists 96 species, 55 of which were new, without listing a single synonym, but omitting 12 old species which he did not recognize. His keys and descriptions fail to recognize the difference between specific, varietal and only sexual characters. In later papers he added 41 more new species still without recognizing a single duplication or error in determination, indicating an adherence to the Walker cult of quantity rather than quality.

Gibson in 1919 published a brief synopsis of the North American forms in which he recognized the extreme variability in the reticulate veined group and brought most of the synonymy of *octolineata* Say together. His material in other groups was not as complete and he failed entirely to recognize the difference in color in sexes and the extreme variability in other species with the result that here the confusion was only increased. He placed much reliance on the presence or absence of black marks on the pronotum and hinges and used it in his keys with disastrous results. This character is widely and commonly variable in a number of species such as *rugosa*, *melanota* and *scarlatina*, and more rarely variable in many others.

The writer some years ago brought together all the then available material from the region of the United States, intending to publish a synopsis of this group following the same lines as his work on the *Tettigonidae*. When the material was assembled it was painfully evident that there had been little or no biological work done on this group and that there were no carefully bred series on which to base a study of the limits of variation. Without such a basis it was evidently impossible to determine the specific limits in this chaos of names so the material was returned and the matter dropped except for the collection of biologic material at every opportunity.

The appearance of Gibson's synopsis with its many obvious errors of reference and synonymy, which if not speedily corrected will cause endless confusion, caused the writer to again look over the situation with reference to available material. A trip to the East, in which a half dozen collections including the National Museum were studied, showed that for at least three of the worst confused species that sufficient material was available so that these species could be properly characterized, the variations in the color and size of sexes correctly pointed out and a large part of the present confusion cleared up.

When it is remembered that the whole 198 names apply to a rather small number of species and that a very large part of the types of these so-called species are in European museums and the only possibility of determining their characters is through meager descriptions it will at once be evident that even though the species be correctly defined it may not be possible in every case to determine the oldest name that will finally apply to a given species. Some further changes in synonymy may therefore be expected when type studies are made. Fortunately or unfortunately, however, we shall have an abundance of names that certainly apply to a considerable number of the species.

Key to the Subgenera of the Genus Gypona.

- A. Vertex and front meeting in an acute angle, the margin more or less produced and foliaceous.
 - B. Venation more or less reticulate. *Gyponana* nov.
 - BB. Venation not reticulate; 5 apical and 3 antepical cells.
 - C. Elytra without dots or lines in the areoles, front broad, our species green or black. *Gypona* Germ.
 - CC. Elytra with dots or lines in the areoles, the front narrow, species cinereous or brown, never green. *Prairiana* nov.
- AA. Vertex and front broadly rounding or with the margin thick and only slightly produced. *Ponana* nov.

Subgenus *Gyponana* Nov.

Resembling *Gypona* in size and form, but with the venation of the elytra broken up into numerous irregular reticulations. Vertex broad, flat, meeting the front in an acute angle the margin foliaceous. Pronotum broad, transverse, striated, elytra elongate, narrowing apically, the appendix very narrow, entire apical area at least broken up into irregular reticulations.

Type of the subgenus *Gyponana octolineata* Say.

The more typical members of this genus are large, broad, green species, with more or less of scarlet or yellow striping. The amount of reticulation is very variable in some species, while quite constant in others.

Key to Species of Subgenus Gyponana.

- a. Costal margin of elytra with fine black dots; whole insect more or less peppered with scarlet and black points.....1. *dracontea*, Gib.
- aa. Costal margin without black dots, whole insect green, often with red or yellow lines.
 - b. Elytra subhyaline smooth, vertex sloping, segment rounding, black spots wanting.....2. *octolineata*, Say
 - bb. Elytra nearly opaque, strongly rugose, shining, vertex flat, female segment rectangularly emarginate, black spots on pronotum and hinge usually present.....3. *rugosa* Spgb.

1. *Gypona (Gyponana) dracontea* Gib.

This small gray-brown species slightly superficially resembles a gray form of *Xerophlæa*. It is by far the smallest of the group in our fauna and is only known from Arizona.

2. *Gypona (Gyponana) octolineata* Say.

This is the commonest and most widespread species in our fauna occurring from Canada to Florida, and from Nova Scotia to California. It varies greatly in size, color and in amount of reticulation and may be divided into varieties as enumerated below. Its reticulate elytra will separate it from all other green species but *rugosa*, from which the almost straight segment and the striping will usually distinguish it. It is apparently a very general feeder on different shrubs and trees.

Var. *octolineata* Say.

Green, washed with scarlet with definite scarlet stripes and more or less scarlet on the heavy reticulations.

Say described this species from Missouri and fixed the name *octolineata* on this variety by describing the markings as scarlet.

and extending on to the reticulations, while he made the form with yellow stripes a variety.

This variety probably occurs throughout the range of the species but is most abundant in the Atlantic coast region.

Var. **striata** Burm.

Gypona cana Burm.; *Gypona flavilineata* Fh.; *Gypona quebecensis* Prov.; *Gypona scrupulosa* Spgb.; *Gypona olivacea* Spgb.; *Gypona geminata* Osh.

Green with six more or less definite yellow stripes on vertex and pronotum. Reticulations very variable.

This form is the most common one throughout the wide range of the species. It was described from Pennsylvania. Burmeister was evidently not aware of Say's descriptions of *octolineata* at the time. *Gypona cana* Burmeister described for Carolina probably represents the heavily reticulate type. The peculiar genital structure described by Burmeister in connection with *cana* has not been found in any member of the genus and was probably based upon a mutilated specimen.

Var. **pruinosa** Spangb.

Examples of a pale, slightly reticulated and usually markedly pruinose variety occurring from Georgia to Texas are placed here.

3. **Gypona (Gyponana) rugosa** Spangb.

Gypona ramosa Kirk; *Gypona delicata* Fowl.

Yellowish green, elytra heavily reticulate, whole surface coarsely rugose shining. Female segment deeply rectangularly notched. Some examples show definite black spots on pronotum behind the eyes and definite pale lines. Others vary all the way from this to entirely wanting.

This very active species is found both as larvæ and adult on the burr and white oak from New York, Wisconsin and southern Colorado, south to Florida and Mexico, and west to Arizona. Gibson separates *ramosa* Kirk, on the black spots, but all gradations in this character are common; *delicata* of Fowler, is evidently an immature example of this species.

Subgenus **Gypona** Burm.

Very large broad leaf hoppers with long, flat vertices sharply angled with the front, the margin thin, and foliaceous. Venation constant, five apical and three anteapical cells. Burmeister

placed *Cercopis glauca* Fab. as his first species and type of his genus. This is a South American species resembling *melanota* but much larger.

Key to the Species of Gypona Burm.

- A. Head broad, vertex rounding, species golden, green or black.
 - B. Broad and stout (*verticalis* excepted), with more or less of black in the males, not confined to the appendix and with black dots on pronotum.
 - C. Vertex short, ocelli closer to eyes than to each other. Dull green, usually with more or less black on median dorsal line.
 - 1. *dorsalis* Spgb.
 - CC. Vertex longer, ocelli equidistant, males frequently shining black.
 - D. Stout, elytra short, female dull green, male green or shiny black, elytra often hyaline.....2. *melanota* Spgb.
 - DD. Slender, elytra long, parallel, female golden, male gold and smoky to shining black.....3. *verticalis* Stal.
 - BB. Species smaller, golden, green or testaceous, without markings except sometimes a smoky line on appendix.....4. *unicolor* Stal.
- AA. Head narrow, vertex angulate, ocelli nearer each other than eye, species pale, no spots or markings.....5. *angulata* Spgb.

1. *Gypona dorsalis* Spg.

Gypona dictitoria Gib.

Big broad, green, unmarked or with variable irregular dark spots and marks mostly confined to the median line, often a pair of round black spots just behind the ocelli, irregular angular markings on scutellum and numerous smaller ones along scutellar and sutural margins of elytra. The dorsum of the abdomen may be dark at the base.

This species occasionally has a few reticulations near the tip of the elytra, but the stout body, shorter vertex and dark markings will separate it from the species of *Gyponana*, while the broadly produced median lobe between two acute lateral ones of the female segment will separate it from all others. Spangberg described *dorsalis* from Mexico, while Gibson described it again from Arizona examples. The writer has examples from New Mexico and Arizona. It is probably confined to the Southwest. Gibson places *dorsalis* as a synonym of *angulata* with a question. They are, however, very distinct as originally described, *dorsalis* being twice as wide as *angulata*.

2. *Gypona melanota* Spangb.

Gypona bipunctulata Woodw. (not Gibs.); *Gypona nigra* Woodw.; *Gypona bimaculata* Gib. (not Spangb.); *Gypona unicolor* Gib. (not Stal).

This is the broadest and shortest of our leafhoppers. Female pale green, unmarked except that they sometimes have a pair

of round black spots on the pronotum back of the eyes and another pair on the hinges. Males varying from entirely shining black to partly black, with milky subhyaline elytra, the black abdominal markings showing through, or in extreme cases entirely pale green, like the females. The female segment is nearly truncate and the male plates are broad and short.

This species is fairly common from Massachusetts to New York and Georgia, west to Minnesota, Iowa and Kansas and almost to the Rocky Mountains in Colorado. It is never found in trees or in shrub-covered areas. It is so heavy bodied that it does not fly readily. The writer has frequently found both sexes, together with the green larvæ in areas of prairie grasses. As there is no other species in this region closely related to this, there can be no question about the relation of the five color varieties of males. Osborn and Ball pointed this out in '97, but both Van Duzee and Gibson have ignored it.

Spangberg described the species from males from New Jersey and Georgia. Either he did not have the female or else confused it with some other species. Woodworth, ignorant of Spangberg's work, described each sex separately. The writer has examined the examples in the Illinois collection and found the above synonym to be correct. Gibson, not recognizing the relation between the sexes, identified the females without black spots as *unicolor*, those with spots as *bimaculata* Spgb. and the dark males as *melanota*. The true *bimaculata* Spgb is, however, evidently the female of the next species and not of this one, and while the real status of *unicolor* is somewhat doubtful, it cannot apply to this species.

3. *Gypona verticalis* Stal.

Gypona mexicana Spangb.; *Gypona bimaculata* Spangb.; *Gypona unicolor* var. *nigrodorsalis* Spangb.; *Gypona nixabunda* Gibs.; *Gypona germari* Stal.

Smaller and much narrower than *melanota*, females resembling *rugosa*. Golden green or yellowish. The females and light males agree in having round black spots on pronotum and black marks on hinge. The males vary from golden green to smoky or shining black, with about five varieties as in *melanota*.

This Rocky Mountain species may be readily separated from its eastern relative by the much narrower and nearly parallel margined appearance, by the golden shade on all but

the darkest males, as well as by its structural characters. The writer has found this species feeding abundantly both as larvæ and adult on the snowberry *Symphoricarpos* sp., in the mountain regions of Colorado. Examples are at hand from New Mexico and Arizona and various places in Mexico south to Vera Cruz.

This and the preceding species need not be confused, as their ranges and food plants are apparently quite distinct. Both species usually carry the black spots on pronotum and hinge but only *verticalis* shows traces of the yellow stripes and that rarely. There has been much confusion and synonymy in this species due to its wide variability. Stal described it twice, both times from males. Spangberg described each sex as a distinct species. Fowler in the *Biologia* described them separately while Gibson added to the confusion by wrongly identifying *bimaculata* and re-describing the green female as *nixabunda*, listing only the dark males as *verticalis*.

Gypona germari Stal is probably the light form of this species. As noted below, Fowler, however, evidently figures and described *angulata* under this name in the *Biologia*, although the two species belong to widely different groups.

4. *Gypona unicolor* Stal.

Gypona unicolor Stal (not Gibs).

The species here listed as *unicolor* is small, compact, pale green without markings except for a slightly smoky shade on the appendix. It is smaller and less parallel in form than *verticalis*, from which it is also distinct by the truncate segment and wide ocelli. The writer took this species in considerable numbers from the clumps of dwarf oaks growing on the mesas at Dolores in Southwestern Colorado and has specimens from Williams, Arizona and Mexico. As noted above Gibson's specimens labeled *unicolor* were all green forms of *melanota* without the black spots. These could not be Stal's species by either description or known range. Stal described *unicolor* as between *verticalis* and *germari* which are probably only color variations of the same species and when the types are critically studied, *unicolor* of Stal may prove to be only the green form of *verticalis*. The present species, however, appears to be distinct in structure, food plant and habit and answers the description in every way. Fowler notes that there is a specimen from Colorado in the Vienna Museum.

5. *Gypona angulata* Spangb.*Gypona tenella* Spgb.; *Gypona germari* Fowl. (not Stal).

The angled vertex, together with the elongate form render this a strikingly distinct species. Superficially it resembles the paler forms of *striata* but lacks the reticulations.

The writer has taken it quite freely on the loco weed (*Oxytropis lambertii*) in the foothills of the Rockies in Colorado and has examples from British Columbia to Vera Cruz, Mexico. This species was described from a male from Texas. Later Spangberg described *tenella* from both sexes from Georgia. No material has been seen that indicates that there are two species in our fauna, and there is nothing in the original description that would separate them.

Gibson places *dorsalis* as a questionable synonym of this species although it was described as twice as broad as *angulata* with an entirely different head.

Subgenus *Prairiana* nov.

Resembling *Gypona* but with a much narrower and longer front and small, widely separated eyes. Vertex flat, elongate nearly equalling the pronotum, angulate, meeting front in a thin, foliaceous margin, ocelli on the disc distinctly in front of eyes. Front narrow and parallel margined in typical examples, often twice longer than wide. Antennal sockets close to front. Species pale gray to brown, entirely peppered with fine fuscous points which margin the nervures of the elytra. Darker examples may have linear markings in the areoles.

Type of the subgenus *Prairiana cinerea* Uhl.

The obscure and uniform coloration of this group is striking and probably an adaptation to the color of the dead grass blades around the margins of the clumps under which they live.

Key to Subgenus Prairiana.

- A. Ocelli farther from eyes than from each other, elytral areoles with dark margins, central markings faint or wanting.
 - B. Front narrow, almost parallel, twice as long as its antennal width, vertex long, convex, irregular. Markings in areoles obscure or wanting, nervures margined with black punctures. 1. *cinerea* Uhl.
 - BB. Front wider, less than twice as long as its width. Vertex shorter. Marking in areoles definite, especially in the male. 2. *miliaris* Stal.
- AA. Ocelli farther from each other than eyes. Antennal sockets touching eyes. Elytral areoles heavily marked with irregular brown areas and faintly margined. 3. *fraudulenta* Spgb.

***Gypona (Prairiana) cinerea* Uhl.**

Uhler described this species from a rather small stout example from Manitou, Colorado. It, however, occurs in a number of quite distinct varieties. They all agree in possessing the long, flat, angulate vertex, the very narrow parallel margined front and the cinereous color with the fine dark punctures. Beyond this they are remarkably distinct and at first would be regarded as extremely well marked species in both size and form. It is possible that the extreme forms *ponderosa* and *subta* may be distinct but in so variable a group it is best to await good life history studies before erecting distinct species when varietal descriptions will serve every purpose and avoid confusion. Gibson refers *cinerea* to the extreme Southwest, but specimens have been examined from Montana, Colorado, Dakota, Kansas, Iowa and Illinois. It is probable that most if not all of the eastern references should be transferred to the next species. This species has never been taken in the mountains and is probably strictly limited to the "short grass" regions.

***Gypona (Prairiana) cinerea* var. *ponderosa* n. var.**

Resembling typical *cinerea* but larger and much broader and heavier. The vertex is so broadened that the apex is broadly rounding rather than angulate. The elytra only equal the abdomen as in typical *cinerea*. The coloration is that of *miliaris* females with the black points back of ocelli large and distinct, the pronotal pits back of these deep and fuscous marked. There are slight fuscous markings in many of the elytral cells. Length of females, 11 mm.; width, 4 mm.

Described from a single female taken by the writer in a meadow on the plains east of Greeley, Colorado.

***Gypona (Prairiana) cinerea* var. *kansana* n. var.**

Resembling *cinerea* but with long narrow parallel elytra and definitely angled vertex. Pale cinereous, finely punctured, the males inclined to be smoky. Length, 9 mm.; width, 3 mm. Described from four examples from Onaga, Kansas, collected by Crevecoeur. This is apparently the most common variety of the species. The writer has collected it sweeping over prairie grass in Colorado and Iowa and Crevecoeur took it abundantly

in Kansas. *Gypona spreta* Fowl seems to be another variety of *cinerea* with a still longer and more sharply angled vertex than *kansana*.

Gypona (Prairiana) cinerea var. *cinerea* Uhl.

Stout gray or smoky cinereous forms with the elytra slightly longer than the body in the females, distinctly folded and narrowing posteriorly giving a stout, short form. The males have slightly longer elytra but are much shorter and stouter bodied than var. *kansana*. This variety has been taken from Colorado and Montana, east to Iowa. Most examples have been swept from upland prairie grasses.

Gypona (Prairiana) cinerea var. *subta* n. var.

Resembling variety *cinerea*, but much smaller and shorter with short rounding elytra exposing the apical segment of the abdomen. These appear to be true brachypterus forms with the appendix wanting and the apical cells rudimentary, but the under wings are as long or slightly longer than the elytra and these forms may make short flights. The females are cinereous, quite heavily irrorate with fuscous, while the males are still darker, appearing in extreme cases as smoky. Length, females, 5-6 mm.; males, 5 mm.

Described from two pairs from Fort Collins, Colorado. Taken by the writer from under the clumps of *Schedonnardus texanus*, a "short grass" clump common on the plains. The larvæ were taken into the laboratory in May. The adults emerged in late May and June. This is remarkably early for this group and appearance might be taken to indicate two generations, but is probably only an adaptation to the early maturity of the buffalo grass and the other short grasses. This variety is quite remarkable in the whole *Gypona* group and superficially resembles an *Acocephalus* or even a *Penthenia*. When compared with the giant variety *ponderosa* it looks like a veritable pigmy. One wonders whether both size and early maturity are not adaptations to "short grass" conditions.

2. *Gypona (Prairiana) miliaris* Stal.

Gypona fraterna Spangb.; *Gypona negotiosa* Gibs.

This species resembles *cinerea* in general form and like that species is widely variable in size and color. The vertex is

shorter and less angled and the front is distinctly shorter and broader. The females are usually much longer and lighter colored than the males, grayish cinereous with minute fuscous spotting. The males are usually heavily irrorate, with fine brown points on vertex and pronotum, while the elytra are brown with the veins lighter and milky spots irregularly distributed in the cells.

This species occurs along the Atlantic and Gulf coast from Connecticut to Texas and Mexico. It does not seem to be a common species far inland, except possibly in the South. A single male from Chicago has been examined. It is probable that the eastern records for *cinerea* all belong to this species and that these two species scarcely if at all overlap in range.

3. *Gypona* (*Prairiana*) *fraudulenta* Spangb.

Gypona marmorata Fowl.

Resembling *miliaris* in general form, but with the ocelli widely separated, and the antennal sockets touching the eyes. Golden yellow, heavily ornamented with brown and fuscous as follows: A line under the vertex margin, a pair of round spots on the vertex behind the ocelli, irregular markings on the anterior portion of the pronotum, two lines on the scutellum and irregular lines in the areoles. A single female from Glen Echo, Maryland, is at hand.

This species is somewhat intermediate in character between *Gypona* and *Prairiana*, but until the whole group is worked up and its affinities established, it should remain in the latter genus.

Spangberg, page 59, of *Species Gyponæ*, describes a species as *marmorata* that is quite different from the one Fowler described so his name would fall in any case.

Subgenus *Ponana* n. sub. gen.

Resembling *Gypona* in general appearance, the body inclined to be cylindrical rather than so definitely flattened. Vertex often much shorter than wide, usually convex, with a rather definite depression before the thickened anterior margin, which is usually indicated above and below, but not produced more than its own width. Vertex and front meeting in nearly a right angle. Ocelli on the disc before the middle. Elytra long and narrow, closely folded. Venation regular.

Type of the subgenus *Gypona* (*Ponana*) *scarlatina* Fitch.

This genus includes a larger number of the blunt headed members of the old genus *Gypona*. The depressed vertex and the thickened margin between vertex and front will at once separate these forms.

Key to the Species of Ponana.

- A. Vertex moderately long and narrow. Species frequently sprinkled with sanguineous.
 - B. Elytra unmarked or with few markings in areoles and those mostly transverse.....1. *scarlatina* Fh.
 - BB. Elytra with numerous markings in the areoles either dots or lines parallel with the nervures.
 - C. Elytral nervures margined with fine dots.
 - D. Small species with head short.....2. *curiata* Gib.
 - DD. Species long and narrow, with larger head...3. *dohrni* Stal.
 - CC. Elytral nervures not margined with dots.
 - E. Fuscous dots numerous.....4. *sanginolenta* Spgb.
 - EE. Sanguineous markings only.....5. *irrorata* Spgb.
 - AA. Vertex broad and short ocelli well before the middle.
 - F. Nervures light margined with brown ocelli definitely back of margin. Pronotum brown with numerous spots on anterior margin.
 - 6. *marginifrons* Fowl.
 - FF. Nervures brown, without margins. Ocelli against the rounding margin. Pronotal spots only behind eyes.....7. *resima* Fowl.

1. *Gypona* (*Ponana*) *scarlatina* Fitch.

This species which Fitch described briefly but accurately in 1851 is one of the most variable of the North American forms, both in color and markings. It varies from almost black to a very light green through shades of olive, brown and scarlet and with equal variation in spots and marks in such numerous patterns that it has been described at least 21 times.

Through all this variation it is a moderate sized active species with a rounding vertex, longer in the middle than against the eye, a definite margin except in the pale forms. The ocelli are before the middle and considerably farther from each other than from the eye. The female segment is very slightly produced and scarcely sinuated. While the male valve is very large, rounding posteriorly with a definite medial callosity back of the margin and often a median carina. The plates are long, separate, curved somewhat like corn husks. They extend at an angle from the pygofer and thus open to view two caliper-like hooks. This and the large ivory posterior lobe of the scutellum are the two most constant characters in the species. The dark markings when present in the elytral areoles are unique in

being inclined to be transverse lines and the spots on pronotum are nearer the anterior margin than those in the preceding groups. While intermediates of various kinds occur, the great majority of the examples fall readily into the following varieties.

Var. *limbatipennis* Spangb.

Gypona albimarginata Woodw.

Vertex and pronotum fulvous, the narrow posterior margin of the pronotum and all of scutellum and elytra, except the narrow creamy costal margins, smoky brown or black.

Spangberg described both sexes from Illinois. The writer has taken dark nymphs from the base of buttercups in a damp meadow in Iowa and obtained this species from them. Dr. Marshall has taken it in Wisconsin and Gibson reports it from New York. This form seems to be the rarest and shades out into var. *pectoralis*.

Var. *pectoralis* Spangb.

Gypona kullensis Prov.; *Gypona bimaculata* Wood.; *Gypona woodworthi* Van D.

Pale greenish yellow, the scutellar disc creamy, an indefinite smoky band arising on posterior margin of pronotum and extending to apex of elytra. A number of irregular black dots on elytra, including a larger and fairly definite pair just back of the center of the disc. A pair of round spots back of ocelli on base of vertex and another pair just behind them are usually faintly outlined in brown. As these spots increase in size and numbers it shades off into var. *puncticollis*.

This is the commonest form of this species throughout the upper Mississippi Valley and extends east to Ontario and the New England States. The writer has taken the brown nymphs commonly from the water sprouts and lower limbs of basswood trees in Iowa and Wisconsin.

Woodworth described a specimen in which the smoky shade had a slightly reddish tinge as *bimaculata*.

Var. *scarlatina* Fitch.

Gypona modesta Spgb.

Pale yellow with a smoky or reddish cast. A number of irregular spots on the disc of the elytra. More or less of scarlet spotting on whole dorsal surface.

This variety is close to *pectoralis*. It is, however, readily separated by the absence of the smoky band and the presence of the scarlet spotting.

Var. **rodora** n. var.*Gypona mediatubunda* Gib. (not Spgb.)

Uniformly pale reddish above and below, with the usual spots on the disc of elytra. The nervures are reddish instead of irregularly smoky as in *pectoralis* and *scarlatina*. There are sometimes traces of scarlet spotting on vertex and pronotum.

Described from a pair from Washington, D. C. Others are at hand from New Jersey.

Var. **puncticollis** Spangb.*Gypona quadrinotata* Spangb.; *Gypona albosignata* Uhl.; *Gypona proscripta* Fowl.; *Gypona hieraglyphica* Fowl.; *Gypona notula* Fowl.

Pale yellowish with reddish cast emphasized on the elytra. A pair of round black spots back of ocelli on pronotum, a pair near each lateral margin behind the eyes, the outer ones larger and a pair on the clytral hinges. The usual spotting on disc of elytra and the narrow line on posterior margin of pronotum. Scarlet spotting often present.

This form replaces *pectoralis* and *scarlatina* in the south and southwest and occurs north to Kansas, Ontario and New York.

Var. **vinula** Stal.*Gypona vinula* var. *ornata* Fowl.; *Gypona propior* Fowl.; *Gypona tergata* Fowl.

Pale greenish yellow with the spots and markings of *puncticollis* and with more or less definite smoky or reddish stripe extending from the scutellar margin down the suture to the apex of the elytra. This is a southern form, extending from Virginia and Florida to Vera Cruz, Mexico. It also resembles and intergrades with *pectoralis*, but is usually smaller and like the other southern forms inclined to a more inflated head.

Var. **citrina** Spangb.*Gypona pauperata* Spgb.

Almost uniform yellowish with a few black spots on the disc of elytra and sometimes faint ones on pronotum. *G. pauperata* was described from an example with scarlet spotting.

This is a southern form, common in Florida and Texas and extending up the Atlantic coast as far as Washington, D. C.

Var. **meditabunda** Spgb.*Gypona cacozele* Gib.; *Gypona occlusa* Gib.

Greenish or greenish yellow with the costal margin of elytra creamy and the appendix smoky brown. The hinge has a

black spot in both sexes. The males sometimes have the two median black points on pronotum and a few on disc of elytra. The head is similar to that in *citrina*, but shorter with the margin even more rounding in some examples.

Spangberg described this form from Texas and gave its color as greenish yellow with a brown appendix. He compares it to *flavicosta* Stal, which has a very short head. Gibson placed this name on a reddish form apparently common in Maryland and New Jersey (see var. *rodora*) and described the true *meditabunda* as *cacozela* and again as *occlusa*, but separating them in the key by the absence of the spot on hinges in *cacozela*, but in the descriptions he gives "elytra with base of clavus darkened" in both cases. As has been shown above, this character is widely variable. All the examples of this form seen have been from Texas. The writer has three examples from Brownsville and one from San Diego, Texas, while all of Gibson's material was from Brownsville.

2. *Gypona (Ponana) curiata* Gib.

A small, dull brownish species with blunt head, faint markings on elytra and the nervures bordered with fine punctures.

Gibson's material was from Arizona.

3. *Gypona (Ponana) dohrni* Stal.

Gypona punctipennis Stal.; (?) *Gypona bisignata* Fowl.; (?) *Gypona reservanda* Fowl.;
Gypona aquila Gib.

A long, slender testaceous or grayish brown species superficially strikingly resembling *Phlepsius majestus* Osb. and Ball. The front is transversely lined with brown, the vertex is almost parallel margined, the ocelli are before the middle and twice farther from each other than from the eyes. There are black spots behind the ocelli, pot-hooks and spots on the anterior sub-margin of the pronotum. The elytra are long, narrow and inscribed with fuscous marks in the cells, with one or two larger ones behind the middle, while the nervures are margined with fine fuscous dots.

Examples are at hand from Grand Junction, Colorado, the Huachuca Mountains, Arizona, and Stal described it from Mexico. It is probably confined to the Rocky Mountain region. Fowler did not recognize either of the Stal species, but apparently described it twice.

4. *Gypona* (*Ponana*) *sanguinolenta* Spgb.*Gypona grisea* Spgb.

Resembling *dohrni* in general appearance, but with a slightly longer flatter vertex and lacking the marginal punctures to the nervures. There are two median punctures on the claval veins, fuscous. The posterior half of pronotum thickly and the areoles sparsely irrorated with brownish points.

Spangberg described this species from Texas and Georgia. It has since been taken as far north along the coast as Pennsylvania and Massachusetts. Spangberg based the difference between *grisea* and *sanguinolenta* upon the latter having the scarlet flaking, a character in which all variations occur in several species.

5. *Gypona* (*Ponana*) *irrorella* Spgb.*Gypona scarlatina* Gib. (not Fitch)· *Gypona grisea* Gib. (not Spgb.)

This species resembles *sanguinolenta* in form and structure but lacks the dark markings of that species. In place of other markings the entire dorsal surface is irregularly flaked with scarlet.

This is a southern species occurring from Texas north and east on the Atlantic coast to Massachusetts but in the interior apparently south of the Ohio River line to Kansas.

Gibson identifies northern examples of this species as *scarlatina* Fitch and refers to a "Fitch type." This type was undoubtedly one of the many "Fitch types" in the National Museum that are not true to type at all in either characters or labels. The writer recently examined the Fitch types at Albany and found that practically all the material of his catalogue was still intact and except for some fading answered perfectly to description and label. Gibson apparently overlooked the fact that Fitch's description calls for black dots on the elytra for he says "but elytra lack the black dots as in *sanguinolenta*." Fitch's material came from Salem, New York, at the base of the Adirondacks which is probably out of the range of this species but in a district where true *scarlatina* and its varieties are common.

G. grisea of Spangberg is described as having heavy black spotting and no red flaking. Gibson on the contrary, sets off two large specimens of *irrorella* without dark markings but with heavy scarlet flaking as representatives of this species.

It is possible that the study of life histories or of more abundant material will show that this and the two preceding species are but variations of a single species which will then be called *dohrni* Stal.

6. *Gypona* (*Ponana*) *marginifrons* Fowl.

This testaceous brown species with its broad, short vertex, dark spots and lines on the anterior part of pronotum, and light elytral nervures narrowly margined with brown is a strikingly distinct and easily recognized species.

The female segment is short with acutely produced lateral angles, between which the posterior margin is obtusely angularly produced and black tipped.

The writer took this species at Dolores, Colorado, feeding on *Rhus trilobata* or a closely related species and other examples are at hand from Arizona. Gibson reports it from New Mexico, while it was described from males taken in Mexico.

Fowler places this species in his group with foliaceous vertices although his own description and figures show that it belongs in the other group, in fact, it is closely related to the species with the shortest and most rounding heads.

7. *Gypona* (*Ponana*) *resima* Fowl.

Gypona bipunctulata Gib. (not Woodw.); (?) *Gypona celata* Fowl.; (*Gypona intertexta* Uhler Mss.)

This pale cinnamon brown species can be readily separated from all others in our fauna by the short, obtusely rounding vertex with the widely separated ocelli placed just back of the rounding margin. It resembles *marginifrons* but lacks most of the pronotal markings; varying from none to two behind each eye, the outer one large. The veins are definitely brownish and the cross veins are slightly marked with fuscous. All the specimens examined from our territory have been from Georgia, Florida and Mexico and it is probably limited to a narrow gulf area in the United States.

Fowler describes *resima* without spots on pronotum but he had only female examples, while *celata* was described from females from Central America as with or without pronotal spots. *Gypona nana* Fowler which appears to be closely related is described as with or without spots.

Gibson's reference of this species to *bipunctulata* Woodw. must have been an oversight as that species was founded on the big, broad, green female of *melanota* and was so described. The writer has examined the Woodworth material (he made no types) in the Illinois Collection and found *bipunctulata* Woodw. and *nigra* Woodw. to be the sexes of the species here listed as *melanota* Spgb. and very distinct from the species described above. Gibson's material was apparently all from Georgia and Florida and the only excuse for the wide range given was probably the supposed Illinois record of Woodworth.

NOTES ON OTHER SPECIES OF GYPONA.

In working over the Mexican species in the course of this study *Gypona atillana* Fowl. and *abjecta* Fowl. appear to be synonyms of *mystica* Spangb., a species described from Mexico but which Fowler did not recognize.

The writer has in his collection four South American species that resemble *melanota* in their color variations. *Gypona glauca* Fab. the type of the genus possesses males varying all the way from the color of the females to shining black. Some of the intermediate forms are highly ornamented with variable patterns of alternate yellow and black. *Gypona vulnerata* Walk, *viridescens* Walk. and *obsesa* Spangb. are variations of one species while *postica* Walk. appears to be the extremely dark form of the male. *Gypona thoracica* Fab., one of the largest species of the group, varies from brilliant green and smoky in the female through all changes and variations of bright red and shining black in the male.

THE WINTER OF 1918-'19 AND THE ACTIVITIES OF
INSECTS WITH SPECIAL REFERENCE TO THE
CLOVER LEAF-WEEVIL
(*Hypera punctata* Fab.)

GLENN W. HERRICK.

Our knowledge of the factors governing the ability of insects to pass successfully through any given winter conditions is very meager. Apparently some winters are very destructive to insect life and bring about a high mortality in the stages that attempt to survive this period while other winters are favorable to the survival of the eggs, larvæ, pupæ, or imagoes as the case may be. The winter of 1918-1919 was certainly a very open and abnormally warm one all over New York State; but it is apparent, from studies made regarding the effect of heat and cold on insect life, that the comparative degrees of humidity, as well as of temperature, must be taken into account if correct generalizations are to be made. For example, as Pierce¹ says: "A creature which can stand a certain degree of cold at a given humidity may be absolutely unable to stand that same temperature at another degree of saturation or relative humidity." Thus there have arisen conflicting interpretations of climatic effects on insects made by different investigators in different localities because they were working under very different degrees of humidity of which no account was taken. It will perhaps not be out of place to give a brief summary of the weather conditions from November to April inclusive as recorded by the weather station at Cornell University:

NOVEMBER, 1918.

"Weather conditions throughout November, 1918, were warm and pleasant, for the most part, with average temperatures generally above the normals in all sections, but the month was a very dry one in all districts, except at few points in the northern part of the State."

DECEMBER, 1918.

"Reports from all sections show that the month was unusually mild with an average excess of warmth of about four and one-half degrees, which is in marked contrast to the severe December of a year ago. A brief spell of zero weather was experienced in the Adirondacks during the first week and again in the northern counties during the

closing days, but otherwise conditions were generally mild and favorable for all forms of outdoor work. Snowfall and precipitation amounts were generally below the normals but were well distributed."

JANUARY, 1919.

"Weather conditions throughout the month were exceptionally mild, as a rule. Two cold spells occurred during the first half of the month, the temperature falling to -20° to -27° in the Adirondack region on the 10th, 11th and 12th, while in the southern and south-eastern sections it ranged from 9° to about -15° . Fortunately the ground was fairly well covered with snow during these severe cold spells, affording a fair to good protection to winter grains, meadows, and new seeding. After the 15th the ground was generally free from snow in most sections, but the temperature average was abnormally high for the season. * * * * Precipitation and snowfall amounts were below the normals at all but a very few stations and pleasant overhead conditions usually obtained."

FEBRUARY, 1919.

"February, like January, was above the normal in temperature and below normal in precipitation. With the exception of 1915 when the temperature averaged 0.3° higher, this was the warmest February since 1891, while precipitation was below normal in all sections, the average of 1.89 inches being the least recorded in the month of February since 1907."

MARCH, 1919.

"The weather of March, 1919, was somewhat above the average both in temperature and precipitation, the excess being 3.4° and 0.56 of an inch respectively. The temperature was above normal in all sections of the State. * * * * The precipitation was above normal in all sections except the Western Plateau and the Mohawk Valley, where it was slightly deficient."

APRIL, 1919.

"The month as a whole, while somewhat colder than the average April, was remarkable for two decidedly cold periods of three days each. The first period covered the first three days of the month, and the second occurred from the 25th to 27th inclusive. The month opened decidedly cold for the season with maximum temperatures generally but little above freezing and minimum temperatures approaching zero in the more elevated parts of the State. * * * * The monthly precipitation for the State was considerably above average."

The weather conditions for the winter of 1918-'19 in New York State may be summed up then as being *above the normal* in temperature and somewhat *below the normal* in precipitation and what is probably as important as either of these there were no

extremes of temperatures except two short cold spells in January when the ground was fairly well covered with snow.

Another factor that must be taken into consideration in any account of the activities of insect life during the season of 1919 is the character of the climatic conditions of the summer following the winter of 1918-1919.

The summer of 1919 was one of normal averages for the months of July and August although there were extremes in July largely because the thermometer went very low at one period. May was nearly normal in temperature but the precipitation was above the normal while June was a month of abnormally high temperatures with precipitation somewhat below the normal and this may have favored the early increase of insects. As a whole, the summer, from a human standpoint, was pleasant and comfortable and a very favorable one for crop production.

The writer is well aware of the danger of making generalizations regarding this phase of insect life. The factors are too involved and there are too many conflicting conditions to make possible any extended generalizations. It is rather commonly held, I think, that insects can better withstand winters with steady low temperatures than seasons of sudden, wide, periodic fluctuations of temperature. We shall probably find, when we have sufficient accurate data, that insects can best withstand winter or summer conditions of even or equable average temperatures accompanied by certain optimum conditions of humidity.

There have been seasons when one or two insects, like the army-worm, May-beetles, rosy apple aphid and green apple aphid have been very abundant but as the author looks back over the last half-dozen years he does not recall a season within that period certainly when so many different species of insect pests were so generally prevalent and destructive as during the past summer. For example, the red-legged grasshopper, *Melanoplus femur-rubrum*, was abundant and destructive over a large part of the State. Say's blister beetle, *Pomphopæa sayi*, appeared in destructive numbers from Utica to near Buffalo. The little black and red Hemipteron, *Cosmopepla carnifex*, a weather barometer apparently, appeared in enormous numbers in several localities. The wheat midge, *Contarinia tritici*, was abundant and injurious over the whole State, while the green

clover worm, *Plathyrena scabra*, occurred from Long Island to Lake Erie and was destructive to vegetables. The old-fashioned potato beetle, *Lema trilineata*, came into prominence for the first time in many years while that other increasing potato pest, the potato leafhopper, *Empoasca mali*, was present in injurious numbers in many localities. The pear slug, *Eriocampoides limacina*, became abundant in certain regions and, in one instance at least, nearly defoliated five acres of cherry trees. The lined corn-borer, *Hadena fractilinea*, scarcely heard of since Webster discussed it in 1894, appeared generally over the State and caused considerable injury. Other examples might be mentioned, but we wish to speak more specifically of the clover leaf-weevil, *Hypera punctata*, and its activities in the spring of 1919.

In some localities the clover leaf-weevil had evidently passed the winter very successfully and in large numbers, and what interested me most regarding it was the numbers of fresh active adults that we found in the fields in the spring. The larvæ were abnormally abundant in many fields in the State and in one or two localities bid fair to cause serious injury. On a farm near Warsaw, N. Y., in a field of eight acres of clover sown the year before to wheat, the larvæ occurred in enormous numbers and for a time devoured the clover about as fast as it grew. On May 17 I visited the field and found the larvæ in all stages of growth although many were nearly full-grown. From six to eight grubs were present at the base of each plant but the conspicuous thing about them at this time was the large numbers of individuals that were dead or dying from the attacks of the fungus *Empusa sphaerosperma*. The sick larvæ had climbed the blades of grass, stems of clover, and stubble of wheat around which each had curled in the characteristic horizontal position. The larva would turn white at first but later would become green and soon die. The progress of the larvæ and of the disease to which they were subject was watched by D. S. Dilts, Assistant Farm Bureau Agent. He informs me that the grubs were so effectively checked by the fungus that they caused no material damage after the middle of May and that the clover recuperated from the early injury and made a fine growth. Similar conditions were observed here at Ithaca. Other observers have recorded the effectiveness of this fungus in holding the larvæ in check in seasons of abnormal abundance. For instance, Folsom²

says "the reported outbreaks of the larvæ in spring have almost always been suppressed by the virulent disease just described (*Empusa*). This disease prevents the summer damage by the beetles, often killing the larvæ before they have done much injury."

Perhaps the most striking feature regarding the weevil was the number of adults that came through the winter in an apparently active condition capable of procreating the species. It is generally supposed that the weevils, although they may survive the winter, are not capable of any activity in the spring. Indeed all that I have ever found hitherto in the spring have been more or less covered with dried mud and were weak and apparently incapable of effectual activity. On this point Folsom¹ says: "I have rarely found the beetles in the early spring, and such as were found were either dead or in the last stages of decrepitude, and evidently incapable of doing anything toward the propagation of their kind."

My attention was first called to these adults by Mr. J. D. Detwiler, who was in the field searching for species of some lesser clover weevils on which he is now working. On March 26 he brought in three adult weevils which were fresh and clean of dirt and active in movement. On succeeding days we were able to find more adults in similar condition. It seems probable that the weevils were similarly abundant and active in the spring in clover fields throughout the State. These beetles were placed in a cage until other beetles were collected in the next few days and on April 5 cages were made ready and the beetles placed in them. The weevils were furnished with fresh clover plants and pieces of old clover stems to provide hiding places for possible eggs. On April 7 I found seven fresh eggs in a hollow clover stem. In another cage, also on April 7, I found one egg on the stipule of a leaf. All of these eggs were removed and placed in shallow tin boxes but owing to dryness, I think, every one of them shriveled and failed to hatch.

On April 19 a group of nine or ten fresh eggs was found again in one of the cages. Again they were deposited in an old hollow stem of clover. These eggs hatched on May 6 or 7. I am not sure which, because at my last examination on May 5 they had not hatched and owing to my absence I did not see them again until the morning of the 8th, when all had hatched. From these eggs I isolated several larvæ, placing each in a shell vial

where they could be watched and fed. Later, when the larvæ became of some size each was transferred to a shallow tin box.

On April 21 I found another batch of nine eggs in a hollow clover stem. Unfortunately, in my desire to watch these closely I opened the stem and later the eggs became scattered in the cage. Those that I could find, however, hatched about May 7. Another batch of eggs found sometime after deposition hatched May 18. In all, four or five batches of eggs were obtained from these beetles.

The lives of the larvæ placed in vials, and later in tin boxes, were somewhat checkered, as one died within a short time, another after the first molt and a third after the second molt. Three, however, came through but one pupated, without spinning a cocoon, on June 8 (I found this to be quite a common occurrence in the tin boxes) and the beetle died without emerging. Another spun a cocoon on June 8 and the adult emerged June 20. This gives a period from egg to adult of 44 or 45 days, depending on whether the eggs hatched May 6 or May 7. A third pupated naked on June 14 and the adult emerged June 20.

From eggs in another cage found May 5 and that hatched May 18, I isolated three larvæ of which one died while two passed through their cycle and both pupated on June 14, while the weevils of both appeared on June 20, only a few hours apart. This would give a cycle of 46 days (from May 5 to June 20).

The vicissitudes of breeding experiments are many, especially where an attempt is made to isolate each larva and to rear it under abnormal conditions. If the larvæ had been left in the cages in more normal environments they would probably have come through more successfully. Indeed, in one of the cages in which I failed to find the eggs and therefore did not remove them the larvæ thrived much better. In view of the foregoing facts regarding egg-laying and development of the weevils the question of a possible second generation presents itself.

Riley⁴ who first investigated this insect in 1881 and '82, says: "This fact, together with the other well-known fact that the Rhynchophora in the imago state are often long-lived and do not begin ovipositing immediately after maturity leads us to believe that there is normally but one annual generation." He qualifies this statement later, however, by saying that "our notes and observations as here recorded would indicate that a second generation may exceptionally occur," and suggests that this might

happen in the latitude of Washington, D. C. Folsom³ says: "In central Illinois we have only one annual generation of this insect, as seems to be the rule elsewhere," and later he also says: "In a warmer latitude than this there might very well be a second generation of beetles, to hibernate and lay eggs the following spring."

It seems to me that our observations and breeding experiments show fairly conclusively that the clover leaf-weevil may survive favorable winters and become active enough in the spring to deposit eggs thus producing exceptionally a second generation in central New York. It will be recalled that November of 1918 "was warm and pleasant for the most part" and that "December was unusually mild with an average excess of warmth of about four and one-half degrees." These conditions may well have given opportunity for many of the larvæ to have reached maturity in the fall and to have transformed to beetles which found favorable weather conditions, during January, February and March. Thus they were able to pass the winter without impaired vitality and deposited eggs in the spring. Moreover, these observations, it seems to me, indicate strongly that farther south where the winter conditions are habitually more favorable, there may be normally a second generation of the weevils.

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SOME OBSERVATIONS ON INSECTS OF THE BETWEEN TIDE ZONE OF THE NORTH CAROLINA COAST.

By Z. P. METCALF and HERBERT OSBORN.

An opportunity for a brief study of the ecological condition prevailing at Wrightsville Beach near Wilmington, N. C., resulted in the determination of the ecological adaptation of several species of Homoptera which have either been entirely overlooked or so little studied that a record of our observations seems worth while. The particular and very interesting ecological situation common of course to long stretches of the Atlantic coast but admirably exhibited at Wrightsville Beach lies in the between tide zone of the inner beach adjoining the sound. This differs from the outer beach facing the ocean in that it is not subjected to the severe wave action of the exposed coast while it gets the full benefit of the rise and fall of the tides. This results in a most luxuriant growth of tidal grasses which are fully adapted to submergence some of them at levels where the whole plant is submerged for hours at a time other species less completely submerged and merging into the zones of *Uniola* which for the most part appear to be above the level of the high tides although the roots and at time portions of the stems are no doubt under water.

These grasses support a multitude of insects among them many Homoptera and these were the objects of our special attention. The most abundant of these were the delphacids (*Liburnia detecta*) but there were other fulgorids, some jassids and one species of cicadid. These insects are fitted in varying degrees to survive the periods of submergence to which they must be subjected but all must have undergone some modification in habit and probably in life history if not in structure to fit them for this mode of life.

It certainly seems rather novel to find these strictly aerial, normally terrestrial insects associated with fiddler crabs and seasnails and maintaining themselves under all the exigencies of tidal forces and alternating aerial and aquatic life. Notes on some of the species observed will illustrate some of the adaptations.

***Tibicen viridifascia* Walk.**

Adults of this species occurred in the grasses of the tidal flats of the Wrightsville Beach on the bay side of the dunes and in many instances the specimens taken were at points evidently below the high tide level. Pupæ were found in considerable numbers attached to the grasses well below the level of high tide and very evidently where they had been attached for the emergence of the adults. Holes were observed at points well below the high tide level which had every appearance of being the openings from burrows which had been occupied by nymphs as they were in the same localities where exuviae were clinging to the stems of grass. Further there were many pupal cases in the drift and these would appear much more likely to have come from a level below tide than above as otherwise it would have been necessary for the cases to have been dislodged from the grass and blown to the surface of the water. From these observations we feel warranted in the conclusion that the nymphal stages of this species are passed in soil that is for a large part of the time under water in fact only exposed at times of low tide.

A little search for egg punctures was rewarded by the finding of such punctures in the stems of the *Uniola* which had every appearance of Cicada punctures and later these were proved both by dissection of eggs from females and on hatching to be such. The egg punctures occurred mostly at a height of two to three feet above ground and in the third or fourth internode of the stem and for all observed at such a level that they were above the level of high tide unless possibly for exceptional high tides. The fresh punctures which were the most abundant ones found occurred in the old stems of the grass apparently stems of last year's growth but in one instance an internode of an old stem contained egg punctures apparently of a former year as well as fresh ones just completed.

The adults fly promptly when disturbed.

The *Cicadellidae* are essentially plant feeding insects adapted to living upon the leaves or stems of their food plants and the species occurring on the tidal flat grasses have undoubtedly adjusted themselves to this condition from ordinary habitats, in all probability simply following the host plant as it has become adapted to this special ecologic condition; an adaptation for both plant and associated insect that must represent the play of ecologic forces through a great lapse of time.

***Deltocephalus littoralis* Ball.**

This species described by Ball in 1905 from specimens collected by VanDuzee at Anglesea, N. J., and since reported from several localities along the Atlantic coast was taken in considerable abundance at Southport, July 28th (1919) and under conditions which showed its adaptation to the between tide habitat very satisfactorily. The grass upon which it occurred was common in certain parts of the tidal flat and where the submergence under high tide was very evident although there was not the indication of such complete submergence as where the *Liburnia detecta* was most common. Adults were abundant and also a nymph which is certainly the young of this species as it was the only nymph of a jassid taken in this association and possesses the distinctive characters of the species so evidently that even without rearing we feel assured of its relation to the adult. These nymphs are quite uniformly greenish yellow without marking except that the eyes appear conspicuously black and the frontal arcs are fairly indicated in whitish on a pale smoky brown background. The length is $2\frac{1}{2}$ mm. It seems obvious that the nymphs and probably the adults also, which showed little tendency to flight, are able to survive considerable periods of submergence and that the species is distinctly restricted to the tidal zone or the grasses occurring there. No record of the occurrence of the species at points incompatible with this view have been made so far as we are aware.

***Deltocephalus marinus* n. sp.**

Another species perhaps even more perfectly adapted for the submergence was taken at Wrightsville Beach, July 27th (1919).

This is a minute species found on a very fine-leaved grass that occurs in extensive mats on areas that are completely submerged at high tide and as the grass is very short it would seem certain that the insect must undergo complete submergence for considerable periods. It corresponds very closely in habitat to the *D. minuta* VanDuzee which abounds in the tidal flat matted grasses of the Pacific coast, especially in the vicinity of Long Beach, California. Our species is much darker above bearing some resemblance to a small *compactus* or to a minute and dark colored *nigrifrons* Forbes (balli VanD.).

The grass on which this species was found, the species undetermined, is apparently restricted in its occurrence and from the patches observed would seem to favor the little depressions or pockets protected from the more violent action of the waves but still sufficiently drained to become fairly dry during the period of low tide.

There is every reason to assume that the whole life history is associated with this grass and although we have not had opportunity to determine as to place of egg deposition or the development of the young we are confident that all these stages will be found associated with this plant when the necessary observations can be made.

As the species appears to be undescribed a technical description is appended.

***Deltocephalus marinus* n. sp.**

A small, slender species, soiled yellowish white in color, with the margin of vertex marked by two or three pairs of fuscous spots. Length 2.25 mm.; width across prothorax .6 mm.

Vertex bluntly angulate, slightly convex, scarcely twice as long on middle as between the eyes, front broad, evenly curved to base of clypeus; pronotum narrower than the head, well produced in front between the eyes, lateral edges rounded, without distinct angles, posterior margin slightly sinuate; elytra extending beyond tip of abdomen, venation distinct.

Color: head yellowish white marked with dark fuscous as follows: eyes, two oblique dashes between eyes and median line, sometimes a pair of large triangular fuscous spots bordering anterior margin of vertex with dots below near the eye as in *balli*, and seven pairs of heavy arcs on front. Pronotum soiled whitish with six faint longitudinal stripes; elytra soiled whitish, veins lighter with more or less fuscous border; legs yellowish the femora crossed by two fuscous bands, one near the middle, broad and another between the middle and the apex; abdomen beneath blackish fuscous with pleurae and genitalia more yellowish.

Genitalia: Female last ventral segment short, about three times as broad as long, posterior margin slightly concave; pygofer rather slender and slightly exceeded by the ovipositor. Male last ventral segment narrow with the apex rather deeply concave, valve broadly triangular, rounded at tip, plates long, two to two and one-half times as long as basal width, gradually tapered to a sharp pointed, upturned and black apex.

Described from 13 males and 14 females collected on small grass below level of high tide Wrightsville Beach, North Car-

olina, July 27, 1919, H. Osborn and Z. P. Metcalf. Type material in collections of authors, North Carolina State College and Ohio State University.

What is quite evidently the larva of this species was collected from the same grass at the same time. Head characters are similar, the general body color is soiled yellowish white, the frons is marked by fuscous arcs and the eyes are blackish fuscous; each segment of the abdomen above from the second to the sixth is bordered by four rectangular black points which are separated from each other by a median white line which runs the length of the abdomen, and also extends forward as a broken stripe over thorax and extends forward on the vertex where it widens anteriorly and fades out near the apex, and by two rows of whitish spots either side of the middle line.

***Dictyophara microrhina* Walk.**

Adults of this species were taken in considerable numbers from beach grasses at about the level of high tide. There was no evidence of their being adapted to complete submergence and as the species occurs on rank lowland grasses away from the coast there is evidently no restriction to the aquatic habitat. The species, however, illustrates the persistence of an insect in following its food plant into conditions of life that must be quite dissimilar from those under which it first formed the association.

***Acanalonia pumila* VanDuzee.**

This species was taken in the same association as the *Dictyophara microrhina* and there is apparently the same or very similar adaptation to the condition prevailing at the high tide line. Among the examples taken were a number which instead of the normal green color were of a dull straw color closely resembling the color of the dead leaves of grass. No evidence as to the place of egg deposition or concerning the early stages was secured but it would seem very probable that the eggs must be laid in such positions that they would be exposed to the submergence at periods of unusual high tide if not in ordinary high tide.

***Myndus enotatus* VanDuzee.**

This species was taken at Southport in a tidal flat much of which was covered with a rather coarse grass and in which *Deltocephalus littoralis* was found in abundance. All specimens of the *Myndus* secured were in the adult stage and no data was secured as to the larval stages. Inasmuch as *Myndus radialis* Osb. occurs under the surface of the ground and on the roots or crowns of grasses growing in low ground notably, so far as observed, in a river bed subject to periodical overflow, it will be a matter of interest to determine if possible whether the nymphal stages of *enotatus* have a similar habit in the tidal flats.

VanDuzee says of *enotatus*: "This form was swept from the grass on the prairies at Haw Creek in untold thousands and in lesser numbers at other localities farther south," but nothing is said to indicate their occurrence in areas subject to inundation.

The species is recorded in VanDuzee's Catalogue for "Georgia and Florida," so the North Carolina record gives it a considerably wider range. Specimens in the Ohio State University Collection from Bay Ridge, Maryland, collected by Prof. J. S. Hine, appear to belong here also and these would agree with a maritime distribution. Whether the species is strictly limited to one species of grass and this one confined to the tidal flats of the Atlantic coast will need to be determined by further study but certainly the species has been able to accommodate itself to the tide flat habitat and there is little doubt that it is able to undergo periods of submergence lasting for a number of hours. There does not appear, however, to be any structural modifications differing from species occurring where no such peculiar condition prevails and as in other species it would seem that the insect has simply been able to follow its food plant into an unusual environment.

***Megamelanus spartini* Osb.**

This species was beaten from the heads of the common "sea oats" (*Uniola paniculata*) which fringe the dunes on and near the tidal flats and while we did not find evidence of this species occurring below tide level the close adaptation of the species to its habitat in the heads of the grass and its relationship to species definitely adapted to submerged conditions seem to warrant mention of it here.

It is apparently identical with the form described from *Spartina patens* and collected at Cold Spring Harbor in 1904.*

While the species is very definitely adapted for the conditions of the head with the parts of bloom and seed and none could be secured by beating or sweeping the leaves or stems there is of course an interesting question as to where the eggs may be laid and whether these are liable to submergence from occurring in parts that may at times be under water. The *Uniola* is for the most part on the parts of the dunes fairly well above high water mark but some of the plants closer to the tide level may very likely be submerged during periods of unusual high tide or severe storms.

***Megamelanus elongatus* Ball.**

Taken only sparingly but on grass of the higher levels of the tidal flats and where the submergence though shorter in duration must be fairly complete.

***Megamelus (Prokelesia) marginatus* VanD.**

A specimen of this species was taken in connection with the abundant *Liburnia detecta* and very evidently fully adapted to the same conditions of life.

It has much the appearance of the *Liburnia* and may easily be confused with that species especially for the macropterous form.

No details of life history have been recorded and we were unable to carry on any studies that would give definite results as to adaptations in the life history that might be credited to the particular environment of the tidal flats. However, it seems fairly certain that the eggs must be laid in leaves or stems of plants subject to much submergence as otherwise we could hardly account for the abundance of the insects, especially micropterous forms, on plants subject to complete submergence at every period of high tide.

Arndt (1914)† has discussed a number of insects living in the between tide zone and among others gives an account of *Megamelus (Prokelesia) marginatus* VanDuzee which is evidently adapted to much the same conditions as the *Liburnia detecta* found at Wrightsville.

* Ohio Naturalist, Vol. V, p. 375.

† Proc. Indiana Acad. Sci., 1914, pp. 323-336.

In his discussion of the special adaptations for survival under submergence he cites the calcar as a structural modification developed as a reaction to the tidal conditions. To appreciate the absurdity of this inference it is only necessary to note that this structure occurs in all species of Delphacinae and, in many other species having no periods of submergence to contend with in their habits there are fully as large and specialized calcars. Arndt says: "The hoods on its feet, the greatly developed proximal segment and the spur are the peculiar modifications which determined that this leaf-hopper should inhabit this particular region." In all these structures this species is in close accord with the other members of the group. We must look elsewhere for any real modifications of structure.

It should be recognized that these insects and hosts of related forms have been for ages adapted to clinging to the stems and leaves of plants and well fitted for withstanding wind and other forces that might tend to dislodge them. The essential factor that the new environment called for was adjustment to submergence in water and this involves especially the ability to hold sufficient quantities of air in or adjacent to the tracheal system to carry over the periods of submergence.

Liburnia detecta VanD. (= *circumcincta* VanD. micropterous form).

This species of Delphacid occurred in great abundance on a grass that grew luxuriantly near the level of low tide and where there were enormous swarms of fiddler crabs. At this level the grass must be completely submerged during high tide and for much of the time during the rise and fall of the tide. It is evident, therefore, that the species both as nymphs and adults and doubtless also in the egg stage must be successfully adapted to survive long periods of submergence, several hours at a time at least. The exact method of protection during this submergence could not be determined but from the shape of the insect, both nymph and adult, it would appear that they can crowd themselves into the spaces between leaf-sheath and stem or into the furrows of the leaf blades in such manner as to hold their attachment to the plant, detachment from which would in all probability mean disaster.

It may be added that this species was not found at any point above the between tide zone and therefore its adaptation to this situation is evidently complete and it is probably restricted to the species of grass which is confined to this habitat.

SUMMARY.

Reviewing these facts briefly it may be said that the adaptation to the submergence of tidal flats at some stage of their existence has been acquired by Homopterous insects of several different families, the Cicadidæ, Cicadellidæ and Fulgoridæ and, for the latter, three principal subfamilies that are so widely separated that we may assume entirely independent origin for the habit. In all then, five groups in which the adaptation is present in greater or less degree. Even in the different genera as *Megamelus*, *Megamelanus* and *Liburnia* there is no reason to assume a common origin since many species in each genus are entirely terrestrial.

Each of the species found in this habitat is closely associated with some one species of plant which in turn must be considered as having been derived from a more strictly mesophytic habitat and the conclusion seems warranted that the insect has simply followed its host plant in this adaptation to hydrophytic habitat.

The structural modifications in all the species studied are practically negligible but there is evidently a considerable physiological modification to accommodate the insect to long periods of submergence under water. The structures fitting the insect for close adherence to its plant host were already developed before the aquatic condition was met and if changed at all would only need intensification to provide against the movement of water. No special adaptations for swimming or skimming on the surface of the water are present although these insects, like practically all others when accidentally thrown on water, will float and may to some extent propel themselves over the surface by active movements in jumping or running.

The physiological adaptations which seem probable present a special problem and one which is apparently of considerable interest but we have not had opportunity to follow it up. It may be noted, however, that insects in general, especially when inactive, are able to survive on a minimum supply of air.

EXPLANATION OF PLATES.

PLATE X.

A general view of the tidal flats at Wrightsville Beach, North Carolina, taken from the higher sand dunes. The plants in the immediate foreground are the sea oats. In the right foreground insert is an adult male *Tibicen viridifascia* Walker resting on a stem of the sea oats.

PLATE XI.

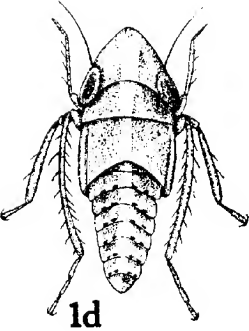
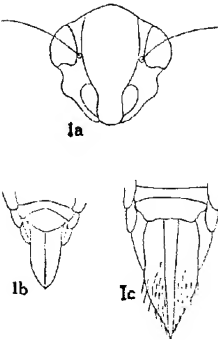
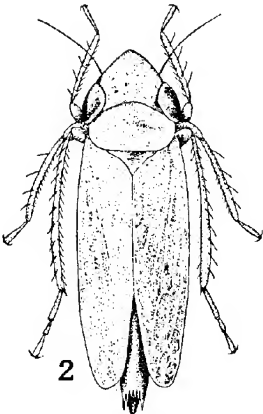
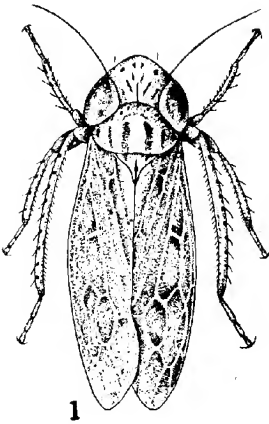
- Fig. 1. *Deltocephalus marinus* sp. n. adult.
- Fig. 1a. *Deltocephalus marinus* sp. n. face.
- Fig. 1b. *Deltocephalus marinus* sp. n. male genitalia.
- Fig. 1c. *Deltocephalus marinus* sp. n. female genitalia.
- Fig. 1d. *Deltocephalus marinus* sp. n. nymph.
- Fig. 2. *Deltocephalus littoralis* Ball.

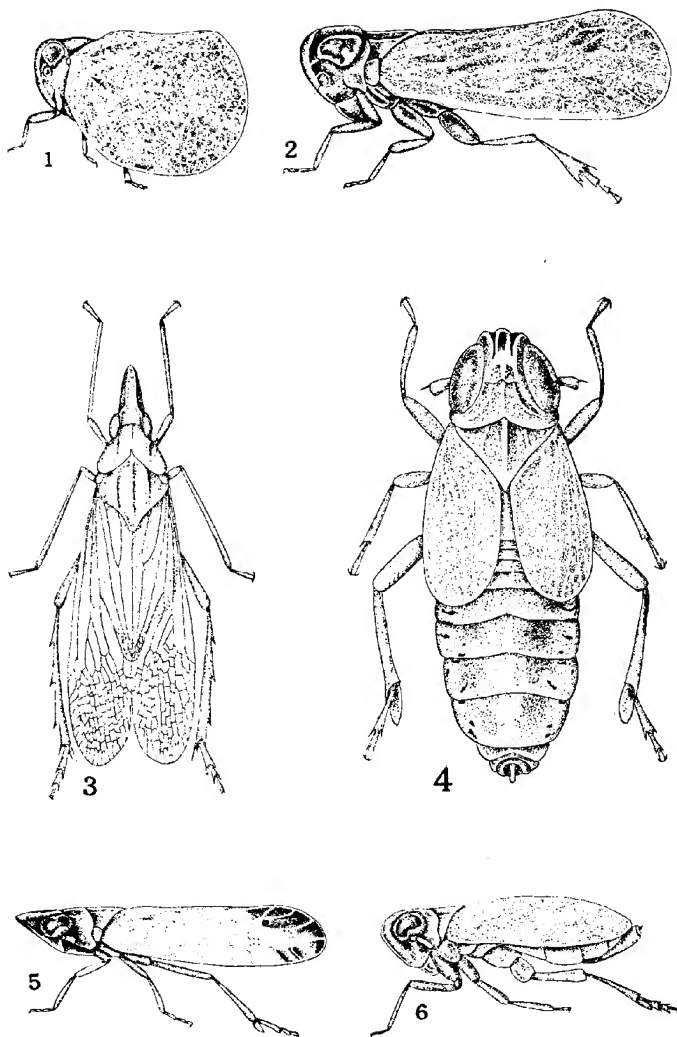
PLATE XII.

- Fig. 1. *Acanalonia pumila* Van Duzee.
- Fig. 2. *Myndus enotatus* Van Duzee.
- Fig. 3. *Dictyophora microrhina* Walker.
- Fig. 4. *Liburnia detecta* Van Duzee.
- Fig. 5. *Megamelanus elongatus* Ball.
- Fig. 6. *Megamelanus spartini* Osborn.



Metcalf and Osborn.





A NOTE ON THE MOUTHPARTS OF THE ARADIDAE

C. S. SPOONER.

The members of the heteropterous family Aradidae are supposed to represent the extreme of dorso-ventral flattening. Certainly they are about as thin as we can imagine possible. We are apt to think that their anatomy, both internal and external, has been modified primarily in this direction. It was with considerable surprise, therefore, that the author, in the course of some morphological studies, discovered a modification of the mouthparts unparalleled, so far as known, in the other Hemiptera and which necessitates considerable dorso-ventral space.

This modification occurs in the mandibular and maxillary setae and is confined to the interior of the head. The head capsule is somewhat modified to accommodate these changed conditions. It will be noticed (Fig. 1) that the clypeus and labrum, known to systematists as the tylus, is curved ventrad and then caudad in the arc of a circle. The suture separating the clypeus and labrum is obsolete, a difference in texture and flexibility marking its probable position. The lateral edges of these sclerites are incurved and extend a considerable distance within the head. These structures form a semicircular sheath.

The mandibular and maxillary setae are articulated in the normal position and become firmly interlocked soon after their origin. They are then coiled, within the head, four or five times anti-clockwise, then they bend sharply and reverse their direction, coiling an equal number of times clockwise. They leave the head capsule at the usual place, just cephalad of the labium and lie in the groove along its dorsal aspect. These coils are closely appressed and the cephalic half of the coil is enclosed by the sheath formed by the clypeus and labrum.

The mechanics of this arrangement are simple. A pull on the proximal ends of the setae would result in the uncoiling of the spring in both directions, forcing the distal end further out of the head capsule. Thus the distance which these setae may be protruded is limited only by the length and contractability of the muscles concerned.

The total length of these setæ, in *Neuroctenus simplex* (Uhl), is approximately six millimeters. In this species they practically equal the total length of the insect. The extent that these may be protruded is not known. The same arrangement has been found in all species of the family which have been examined, some six species. It is also found in the nymphs.

The biology of these interesting insects is but imperfectly known. Of course, they are found exclusively under comparatively loose bark and supposedly feed upon the juices of

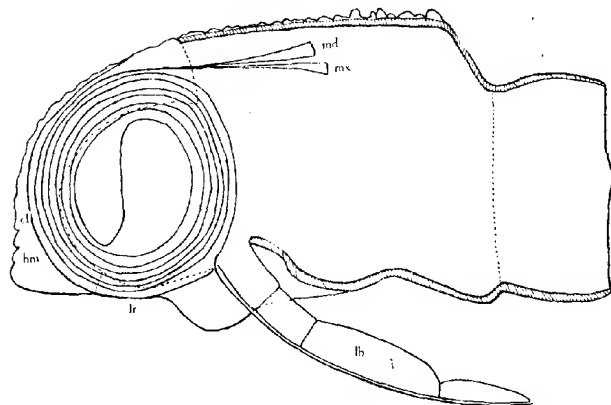


FIG. 1.

Longisecton of head of *Neuroctenus simplex* (Uhl). (Diagramatic).

cl—Clypeus; *hm*—Hemimaxilla; *lb*—Labium; *lr*—Labrum;
md—Mandible; *mx*—Maxilla.

decaying wood and bark. Their methods of feeding are unknown, in fact, their very food supply is probably only inferred. We are therefore unable to state what purpose, if there be a special purpose, this modification serves.

It may be well to mention here the fact, as pointed out by Reuter,* that the labium consists of four segments instead of three, as given in most of the American texts and tables.

*Reuter, O. M., Neue Beiträge zur Phylogenie und Systematik der Miriden. Acta Soc. Sc. Fenn. T. 36, No. 3, 1910.

MINUTES OF THE ANNUAL MEETING.

FIRST SESSION.

The Fourteenth Annual Meeting of the Entomological Society of America was opened in Soldan High School, St. Louis, Missouri, at 2:00 P. M., Monday, December 29, 1919, with Vice-President J. W. Folsom in the chair. On motion from the floor, C. L. Metcalf was elected Secretary *pro tem*. The following Committees were appointed by the chair:

Committee on Nominations: RAYMOND C. OSBURN, T. D. A. COCKERELL, and WM. A. RILEY.

Auditing Committee: SEYMOUR HADWEN, C. H. TURNER and J. L. KING.

The Chair appointed ARTHUR GIBSON and GEO. A. DEAN to fill vacancies on the Executive Committee.

This session was devoted to the reading of the following papers:

- Tropisms in Insect Behavior—An Inquiry.....C. H. TURNER
The Food Plants and Distribution of Certain Calandra Species..
A. F. SATTERTHWAIT
The Biology of the Carabid Genera *Brachynus*, *Galericita* and
Chlaenius.....J. L. KING
Insects of the Between-Tide Zone of the North Carolina Coast....
Z. P. METCALF and HERBERT OSBORN
Observations on Canadian Ticks.....SEYMOUR HADWEN
Notes on the Mouth-parts of *Aradidae*.....C. S. SPOONER
The Genitalia of the *Syrphidae*.....C. L. METCALF
Observations on the Genitalia of *Lachnosterna*.....
WM. P. HAYS and J. W. MCCOLLOCH
Notes on the Leafhoppers of the Subfamily *Gyponinae*.....E. D. BALL
The Production of Abnormal Larvæ, Pupæ, and Adult Beetles by
Gas Secreted by the Confused Flour Beetle (*Tribolium confusum*).....R. N. CHAPMAN

SECOND SESSION.

TUESDAY, DECEMBER 30, 10:00 A. M.

The Society was called to order by the President, J. G. Needham, in Soldan High School at 10:00 A. M. This session was devoted to a Symposium on "The Life Cycle in Insects."

Scope:

1. Facts as to form changes, broods, length of life, moults.
2. Significance of facts in relation to nature of environment, reproductive capacity, rate and times of growth; habits, etc. Briefest possible statement of what each group best illustrates in relation to the life cycle.

Presentation by groups, as follows:

1. Apterygote Insects.....J. W. FOLSOM
 2. Orthopteroids (sens. lat.).....E. M. WALKER
 3. Hemiptera (excl. 4).....E. D. BALL
 4. Aphids and Coccids.....EDITH M. PATCH
 5. Neuropteroids having complete metamorphosis, and Lepidoptera.....S. L. FRACKER
 6. Coleoptera (incl. Strepsiptera).....R. N. CHAPMAN
 7. Diptera.....C. L. METCALF
 8. Hymenoptera.....T. D. A. COCKERELL
- Concluding Discussion.....S. A. FORBES

THIRD SESSION.

TUESDAY, DECEMBER 30, 2:00 P. M.

The Society was called to order in business session in Soldan High School by President Jas. G. Needham.

Dr. F. E. Lutz moved that it is the sense of the Society that it be desirable to have the papers on the Life Cycle in Insects published in one number of the ANNALS. Motion carried.

Motion was passed to hear the papers remaining on the program before the business session. The following papers were heard:

- The Influence of Environmental Factors in the Hatching of the Eggs of *Aphis prunifoliae* Fitch.....ALVAH PETERSON
- Serum Diagnosis and Insect Relationships.....ROBT. D. GLASGOW and JOSEPHINE BURNS GLASGOW

The Executive Committee presented the reports of the Secretary, Treasurer, Editor of *ANNALS*, and Treasurer of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

Membership.—The following members have died since the last Report:

EMERSON LISCUM DIVEN, killed by the fall of an aeroplane while engaged in government work.
 V. A. E. DAECKE.
 O. S. WESTCOTT.
 F. H. WOLLY-DOD, died in army service in the Balkans.
 Total, 4.

The following have resigned:

DR. JAS. F. ABBOTT.	MAURICE E. HAYS.
GEO. F. ARNOLD.	WM. KAYSER.
W. B. BARROWS.	ALICE A. NOYES.
R. P. DOW.	F. X. WILLIAMS.
S. W. FOSTER.	
Total, 9.	
For non-payment of dues, 17 members were dropped.	
Total losses, 30.	

On September 20th, the following were elected to membership by the Executive Committee:

HAROLD M. BOWER.	STANLEY R. McLANE.
P. W. CLAASEN.	H. RAYMOND PAINTER.
F. C. CRAIGHEAD.	I. L. RESSLER.
JOS. J. E. GILLET.	BENJ. G. THOMPSON.
ARTHUR FRANK.	COLBRAN J. WAINWRIGHT.
Total, 10.	

On December 29th the Executive Committee elected the following:

GEO. H. BRADLEY.	ROBT. L. KING.
WM. C. COOK.	FLOYD LAMBERT.
R. A. CUSHMAN.	RICHARD N. LOBDELL.
A. G. DIMOND.	STEWART LOCKWOOD.
HERBERT L. DOZIER.	PHILIP R. LOWRY.
MARVIN DUNN.	ENOCH A. McMAHON.
ALFRED E. EMERSON.	H. H. NISINGER.
ROBT. K. FLETCHER.	R. H. PAINTER.
LAURA FLORENCE.	H. T. SEIFERT.
PERRY A. GLICK.	MARION R. SMITH.
WM. P. HAYES.	WM. SCHAUS.
CHAS. C. HILL.	HERRERT SPENCER.
HARRY A. HORTON.	J. R. STEAR.
Total, 26.	

Total additions, 36. Net gain in membership, 6.

War Service and Remission of Dues.—In accordance with the resolution passed at the last Annual Meeting, the Secretary has endeavored to procure a definite statement from each member who was in naval or military service of the United States and Allies, and has credited, subject to the approval of the Executive Committee, an amount of dues covering the period of service, with a minimum of one year. The following have made statements and received credit (in the absence of definite instructions on the point, the Secretary has taken the date of the armistice as the termination of the period of remission):

J. W. BAILEY.	NEALE F. HOWARD.
J. P. BAUMBERGER.	L. O. JACKSON.
F. H. BENJAMIN.	J. L. KING.
L. L. BUCHANAN.	H. H. KNIGHT.
R. T. COTTON.	W. H. LARRIMER.
HOWARD CURRAN (Canadian).	C. E. MICKEL.
D. M. DELONG.	MARTIN E. MOSELY (British).
E. L. DIVEN.	PHILIP A. MUNZ.
JAS. C. EVENDEN.	GEO. B. NEWMAN.
JOHN R. EYER.	J. SPEED ROGERS.
HARRY L. FACKLER.	G. J. SPENCER (Canadian).
F. A. FENTON.	E. H. STRICKLAND (Canadian).
THEODORE H. FRISON.	JOHN N. SUMMERS.
RICHARD T. GARNETT.	J. B. G. TULLOCH (British).
EDMUND H. GIBSON.	D. L. VAN DINE.
MAURICE E. HAYS.	CHAS. A. WEIGEL.
MORGAN HEBARD.	R. C. WILLIAMS, JR.
WALTER N. HESS.	WM. C. WOODS.
J. D. HOOD.	

A total of 37 individuals, representing 49¼ years service. \$98.50 in all has been remitted in dues.

There are a few more to hear from.

Regarding payment of dues, the members were in the following classes on December 22d:

Paid for 1919.....	425
Owing one year.....	55
Owing more than one year.....	68
New members not yet paid.....	36
Life members.....	11
Honorary Fellows.....	6
Total membership.....	601

Four life memberships have been taken since the last report: By E. D. Ball, G. C. Crampton, J. F. Illingworth and J. Bequaert.

Respectfully submitted,

J. M. ALDRICH, *Secretary*.

December 22, 1919.

TREASURER'S REPORT.

December 17, 1919.

RECEIPTS.

Balance Dec. 23, 1918 (Annals, Mar., 1918, p. 60).....	\$1,173.99
Dues of Members.....	930.00
From Managing Editor of Annals.....	395.77
Interest on Current Account.....	16.60
Interest on Permanent Funds.....	28.27
One Life Membership in cash.....	50.00
Exchange.....	.06
Total.....	<u>\$2,594.69</u>

DISBURSEMENTS.

Annals for 1918—March.....	\$302.50
June.....	296.00
September.....	244.00
December.....	325.00
Engraving for Annals.....	53.17
Postage and envelopes, Annals.....	35.20
Clerical help, Annals.....	18.45
Stamps and stamped envelopes, Secretary.....	23.00
Printing, Secretary.....	20.58
Clerical help, Secretary.....	35.00
Telegrams, two, in arranging symposium.....	2.00
One War Savings Stamp.....	4.23
Balance, cash in Commercial Nat'l Bank, Washington \$1,211.40	
In Fowler Nat'l Bank, Lafayette, Ind.....	24.16
	<u>1,235.56</u>
	<u>\$2,594.69</u>

NOTE.—The one War Savings Stamp was purchased with \$2.00 interest on Permanent Fund, plus \$2.23 of the balance of \$2.74 of Permanent Fund which was carried over uninvested at last report. The balance, 51 cents, of this uninvested item, is still carried in our bank balance above, as is also one Life Membership which belongs to the Permanent Fund, but was received so recently that the matter of its investment was left to the Executive Committee at the present meeting.

CONDITION OF PERMANENT FUNDS.

On hand last report (Annals, March, p. 60).....	\$586.58
E. D. Ball, life membership.....	50.00
G. C. Crampton, life membership.....	50.00
J. F. Illingworth, life membership.....	50.00
J. Bequaert, life membership.....	50.00
One War Savings Stamp (see note under Disbursements).....	4.23
Appreciation of 10 War Savings Stamps.....	1.20
Interest.....	28.87
Total.....	<u>\$820.88</u>
Less interest transferred to current fund.....	26.87
Present balance.....	<u>\$794.01</u>

SECURITIES HELD.

Bonds reported last year.....	\$550.00
10 War Savings Stamps, present value.....	43.50
U. S. Bond, No. 9,938,349.....	50.00
U. S. Bond, No. 1,747,437.....	50.00
U. S. Bond, No. 14,145,890.....	50.00
Cash balance, carried in current fund.....	50.51
Total.....	<u>\$794.01</u>

Respectfully submitted,

J. M. ALDRICH, *Treasurer*.

Washington, Dec. 17, 1919.

REPORT OF THE MANAGING EDITOR.

It will very likely be taken for granted that in the publication of the *ANNALS* we have had to meet some of the difficulties and discouragements that seem to have troubled most of the enterprises of the year. It will not be necessary to detail them here but we trust that those who have been inconvenienced by delays or errors will accord the charity that is granted other delinquents. In spite of unfavorable conditions our subscription list has been well maintained, a number of back volumes have been sold and a number of authors have very generously assisted in the expense of providing illustrations for their papers.

Our expenses have been kept at the lowest point possible with due regard to creditable publication and we have been fortunate in continuing contracts for printing with but slight advances in certain details. However, a readjustment involving an advance to cover higher cost of paper will have to be met the coming year.

Receipts of the office have amounted to \$422.70, of which \$398.77 have been turned over to the Secretary-Treasurer, the balance being used for minor items of expense indicated in the following summary:

RECEIPTS.

Subscriptions.....	\$259.00
Sale of back volumes.....	117.75
Reprints and engravings.....	45.95
Total.....	<u>\$422.70</u>

DISBURSEMENTS.

Stamps and postal deposits.....	\$ 17.43
Labor.....	2.50
Refund on double subscription.....	4.00
By balance paid to Treasurer.....	398.77
Total.....	<u>\$422.70</u>

I believe we may feel proud of the character of articles published during the year and there is in hand a supply of excellent material for the coming year. If we are to enlarge the *ANNALS* to take care of the desirable papers offered we will need a larger income and this must be sought in a larger membership, an advance in membership and sub-

scription rates or in a larger sale of back volumes of which we have still a fair reserve. It is certainly desirable to maintain as wide a circulation as possible and while the price of the *ANNALS* is low compared with other journals it may be best to attempt to carry it forward another year or two, at least, at the old rates. A very decided help would be given if members would fill out their sets of back volumes or assist in placing sets in libraries which have not a complete series.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor*.

The Executive Committee reported that they had made the following appointments:

Thomas Say Foundation, three years: NATHAN BANKS and A. D. MACGILLIVRAY; two years, C. GORDON HEWITT and WM. T. DAVIS.

Editorial Board: S. A. FORBES, A. D. HOPKINS and A. L. LOVETT.

The Auditing Committee reported as follows, and on motion the report was accepted:

The Auditing Committee have examined the books of the Editor of the *ANNALS* of the Entomological Society of America and the Treasurer of the Thomas Say Foundation and have found the same correct.

S. HADWEN,
C. H. TURNER,
J. L. KING.

Committee.

In the absence of the Secretary-Treasurer, his books were audited by a special committee of the Society in Washington, D. C., who made the following report, which was accepted:

Your Committee has examined the records and vouchers reported by the Secretary-Treasurer, J. M. Aldrich, and find the same to be correct and properly kept.

H. S. BARBER,
A. N. CAUDELL,

Committee.

The Committee on Entomology in the National Museum presented a report, and following a discussion the report was accepted with the adoption of the following motion:

Moved, That this Committee be empowered to combine its report with that of the Museum Committee of the American Association of Economic Entomologists; that an abbreviated report based on the two separate reports be printed for publicity purposes, half of the expense to be borne by the Entomological Society of America; that the National Research Council be informed of the needs of the National Museum and their consideration and support be urged.

The combined report is printed at the end of these minutes.

The Nominating Committee submitted the following nominations:

President—L. O. HOWARD.

First Vice-President—F. E. LUTZ.

Second Vice-President—EDITH M. PATCH.

Secretary-Treasurer—J. M. ALDRICH.

Additional Members Executive Committee—W. S. MARSHALL, G. A. DEAN, J. W. FOLSOM, G. W. HERRICK.

Committee on Nomenclature—E. P. FELT, T. D. A. COCKERELL, NATHAN BANKS.

Committee on Entomology in the National Museum—C. W. JOHNSON, HERBERT OSBORN, WM. BARNES, W. M. WHEELER, J. G. NEEDHAM.

On motion the Secretary was instructed to cast the ballot of the Society for the candidates nominated. This being done, they were declared duly elected.

FOURTH SESSION.

8:00 P. M. The Society was called to order by President Needham, who introduced Dr. Wm. J. Holland, Director of the Carnegie Institute. Doctor Holland gave the Annual Address upon the subject "The Evolution of Entomological Science in North America." The address is printed in this number of the ANNALS.

The Society then adjourned.

C. L. METCALF.

Secretary pro tem.

ENTOMOLOGY IN THE UNITED STATES NATIONAL MUSEUM

The day has long passed when American scientific activities can be restricted to a narrow field. Whether we regard the economic needs or the intellectual development, we find ourselves compelled to consider the whole range of science, limited only by our resources and the powers of the human mind. In the field of Entomology this involves, among other things, access to adequate collections of insects, including not only those found in North America, but the species of the whole world. The leading European countries have long appreciated such needs, and have built up collections to which Americans have to make pilgrimages when engaged in comprehensive studies of insect groups. There is no reason why we should not possess facilities for work at least equal to those of any other country. We have the greatest material resources of any nation at the present time, and certainly are not lacking in the ability to carry on the work.

The species of insects are far more numerous than those of any other group of animals; in fact the described forms exceed those of all other groups combined. Very many of them are of supreme importance and interest to man, as destroyers of our crops, carriers of the germs of disease, enemies of other injurious insects, or sources of some of our most important economic products. All know the value of the silkworm and the honey bee, but few realize the services of the best of parasitic insects, which keep down the enemies of our crops, and without which agriculture would be impossible. All are aware that numerous insects are injurious to plants, but comparatively few know that many of the most harmful of these have been introduced from abroad. The greatest danger to our crops, or even to our health, may arise from insects accidentally brought from foreign countries through the operations of commerce. The San Jose scale, dangerous enemy of many fruits, came from Asia; the cottony cushion scale, which once threatened the extinction of the orange industry in California, came from Australia. The gypsy moth, which has cost this country hundreds of thousands of dollars to fight, is European. The cotton boll weevil, even more to be dreaded, invaded the United States from Mexico and Central America. For urgent practical reasons, therefore, as well as in order to complete and organize our knowledge, we need to know the insects of all countries, and to have them represented in at least one American collection.

This obvious requirement of a great collection representing the insects of all lands, cannot be met without Congressional aid. The National Museum, under present conditions, or better, limitations, cannot possibly adopt an adequate policy of entomological development. The two prime obstacles are lack of sufficient curators and lack of space. The present force of curators, even with the aid afforded by the members of the Bureau of Entomology, cannot arrange and classify the collections already on hand, incomplete as these are. Some of the men work overtime and on holidays, while help is sometimes obtained from those not officially connected with the Museum. But all these

activities lamentably fail to meet the whole need. The Museum should have enough expert curators to keep classified and in order, the available material in every group of insects, and to furnish identifications and other aid to economic entomologists and other workers in every State. Should a sufficient curatorial force be supplied, however, it would be helpless in the present crowded condition of the department. There is hardly room to move around, and almost no space for new cabinets. The only way out seems to be through the erection of a new building of suitable size; fireproof, but not necessarily of any great architectural pretensions.

Granting the building and the curators, with suitable rules and arrangements to ensure the proper care of all the collections, what more should be demanded? Undoubtedly collectors and students would present or bequeath their materials on a scale previously unheard of, because of the great services they had received from the Museum and their confidence in it as a repository of types and other priceless specimens. This, however, would not suffice. Funds should be available for explorations within the United States and abroad, to discover insects hitherto unknown or unrepresented in the Museum.

With curators, building, and adequate collections, we are still confronted by another urgent need. The results of the work done must be made available to scientific men in every part of the country. This can only be brought about through the creation of adequate publishing facilities, insuring the reasonably prompt appearance of each work completed. At the present time authors hesitate to undertake large monographs not knowing when they will see the light of publicity, nor indeed whether they will ever do so.

Prepared by the Committees to investigate conditions and needs of the United States National Museum.

<i>Entomological Society of America:</i>	<i>American Association Economic Entomologists:</i>
T. D. A. COCKERELL, Professor of Zoology, University of Colorado.	JOHN J. DAVIS, In charge, Japanese Beetle Project, New Jersey State Department of Agriculture.
HERBERT OSBORN, Research Professor, Department of Zoology, Ohio State University.	VERNON L. KELLOGG, Secretary, National Research Council.
WM. BARNES, Surgeon, Decatur, Illinois.	E. P. FELT, State Entomologist, New York.
WM. M. WHEELER, Dean Bussey Institute, Harvard University.	HERBERT OSBORN, Research Professor, Department of Zoology and Entomology, Ohio State University.
J. G. NEEDHAM, Head, Department of Entomology, Cornell University.	E. D. BALL, State Entomologist, Iowa.
	<i>Committee.</i>

(Approved and adopted at St. Louis, Missouri, by the Entomological Society of America, on December 30, 1919, and by the American Association of Economic Entomologists, on January 2, 1920.)

